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ABSTRACT

This 68-paper collection represents a broad mix of telecommunications issues, problems, innovations, needs and resources, from a conference organized by the Pacific Telecommunications Council, an independent, voluntary-membership organization dedicated to the beneficial development and use of telecommunications in the broad Pacific area. Papers are organized generally by topics and include the following categories: institutional barriers to users; communications networks (application, measurements, design, and development); international issues and planning; World Administrative Radio Conference (WARC) issues; Pacific Island telecommunications; future directions of telecommunications standards; user experience and perspective; public service and educational uses of telecommunications; the consumers for telecommunications services; legal issues arising from the use of international information networks; telecommunications hardware systems; technology transfer (appropriate communications systems in the Pacific and Asia); social effects of telecommunications; demand, rates and regulation issues; transmission system quality control; the information economy; and the future of Pacific telecommunications. Most of the papers are prefaced with an abstract and include references. (LMM)

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PTC '81

PACIFIC TELECOMMUNICATIONS CONFERENCE

Papers and Proceedings of a Conference
held January 12-14, 1981
at the
Ilikai Hotel, Honolulu, Hawaii

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FOREWORD

This is the third year I have had the pleasure of editing the Pacific Telecommunications Conference Proceedings. During the past three years we have watched PTC grow into an exciting and unique forum concerned with the problems and possibilities of telecommunications in and around the Pacific. That this is a broad based dialogue is well evidenced by the spectrum of contributions included in this volume. Here contributors representing a diversity of backgrounds, cultures and interests come together to share information and insights on present and future telecommunication developments—developments that set the conditions for the emerging Pacific communication and information era.

Past PTC conferences have had as their objective, the bringing together of communication professionals. The concerns of telecommunication users, suppliers, researchers, academicians and others are reflected in past PTC proceedings. Now, in 1981, we assemble again to discuss topics that affect the technical, economic, regulatory and social telecommunication futures of the Pacific.

These papers represent a broad mix of telecommunication issues, problems, innovations, needs and resources. The works in this volume have been arranged to facilitate the use of the papers as the conference unfolds. The first day sessions are indicated by an "A" preceding the order of each session's presentation. The second and third days are indicated by the letters "B" and "C," respectively.

We hope that you benefit from and enjoy the 1981 Pacific Telecommunications Conference. On behalf of the authors, the conference organizers and sponsors, I would like to extend a warm aloha to you.

Dan J. Wedemeyer
Editor, 1981

CONFERENCE ORGANIZATION AND SPONSORS

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PTC '81 is organized by the Pacific Telecommunications Council, an independent, voluntary membership organization dedicated to the furtherance of beneficial development and use of telecommunications in the broad Pacific area.

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THE NEW ECONOMICS OF PACIFIC TELECOMMUNICATIONS

Roger P. Vallo
President
GTE Communications Network Systems

SUMMARY

The magic combinations of the new technological possibilities and deregulations force one to re-examine the economics of telecommunications solutions to increase dialouge and aid progress in the Pacific region. In most cases it can be shown that advanced telecommunications can be introduced more rapidly than was envisioned even five years ago for the small island state as well as the large continent. The Pacific region is of particular interest to telecommunicators as satellites eliminate the problem of separation over thousands of miles of ocean and new services such as electronic mail allow for rapid and inexpensive information exchange. In addition, the Pacific region as evidenced by these conferences contains a wealth of telecommunications talent. The new telecommunications will ensure that this talent remains in contact with the state-of-the-art worldwide.

NOTES

THE DEVELOPMENT OF TELECOMMUNICATIONS IN THE PACIFIC REGION

Kiyomi Yukihiro
President
Research Institute of Telecommunications and Economics, Japan

SUMMARY

In the Pacific Basin many countries are scattered and separated from each other by the ocean. Most of them are now at the developing stage and are eagerly looking for the information and communication infrastructures which are considered key elements for their future development. On both sides of the Pacific Ocean, however, there exist industrialized and information-affluent countries, and they are concerned about information and communication problems in developing countries in the Basin.

To cope with these requirements and problems, new communication media are emerging in succession in major advanced countries. They have been developed as a result of "convergence" of communication and information technologies, and are expected to be effective and indispensable tools for the improvement of understanding and development of the society and the economy of the countries of the Basin.

The Pacific Telecommunications Council is now confronted with the second-stage programs after the successful establishment of its organization. In order to realize the PTC's objectives, it is considered necessary to objectively grasp and analyze the present status of society, economy, culture, telecommunications and so forth in the Pacific region, as well as to forecast and plan on a scientific and appropriate basis for the future from the long-term viewpoint. Therefore, it seems important for the future development of PTC to promote the basic researches in these areas, to push forward fair and free study activities, to hold seminars and lecture meetings, and to meet the needs of various countries in the region by taking advantage of its merit as a non-governmental organization. PTC should contribute to the development of telecommunications in the Pacific region through these activities.

NOTES

TELECOMMUNICATIONS DEVELOPMENT: SINGAPORE AND ASEAN COUNTRIES

Frank Y. C. Yung
Chairman
Telecommunications Authority of Singapore

SUMMARY

The Pacific Basin Area, in particular the ASEAN countries, has been credited as one of the fastest economic growth regions in the world. The economic expansion has gone hand-in-hand with greater scale and scope of the provision of telecommunication services

The purpose of this paper is to illustrate the background of development and growth of telecommunication services in Singapore, the philosophy and some of the effects on Singapore's telecommunication policies. It outlines the future direction and role of telecommunications in Singapore, towards the economic growth and social development in a developing country and observes cooperation between telecommunication administration of ASEAN countries.

NOTES

Policy Issues in Planning for Distance Education Using a Domestic Communication Satellite

J. Eric Gough, Brian J. Garner and Ronald K. Day
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Abstract

The authors briefly review the use of satellite technology for educational purposes and give an overview of distance education in Australia to indicate potential satellite usage.

A number of policy issues that need resolution at government and institutional level are identified and discussed.

The paper concludes by discussing the range of educational options generated by the new technology and draws some scenarios for tertiary education in the late eighties.

INTRODUCTION

The decision that Australia would have its own communication satellite system was announced in the press on 17th October, 1979 (1). This announcement climaxed considerable debate in which markedly opposing positions were adopted. Since then a Satellite Project Office has been set up with the responsibility, among other things, for preparing a design brief for the satellite by June 1980. With such a tight timetable there is little hope that user needs can be adequately explored, with the consequence that the first generation satellite may have more limitations than most would wish.

It is not the point of this paper, however, to criticise the planning schedule but rather to underline the importance of users paying a great deal more attention to understanding the capabilities of the system, identifying the new options it presents, and developing appropriate strategies to exploit the new technology. This paper addresses itself to some of these issues within the context of distance and further education particularly at the tertiary level.

TECHNOLOGY AND ACCOUNTABILITY

Education today is being called into question perhaps more than ever before. The growth of the total education budget over the past decade or so has heightened the call for accountability. Particularly in the tertiary sector it would seem that universities and colleges cannot expect increased funding while the economy remains under pressure. Thus the effectiveness of tertiary institutions in meeting their objectives is likely to be subject to regular and increasing audit. substantial changes have occurred in the tertiary education sector since World War Two. Vast increases in enrolments, changes in the composition of student population, a proliferation of institutions and even the birth of new types of institution are among the more notable.
During this period of growth and change, advances in technology have been accommodated but essentially as supplementing rather than changing the educational process dramatically.
Technological progress over the next few years, however, may well be such as to require radical changes in structure and process(2). Clearly, the universities and colleges of advanced education should be in the vanguard of thinking and planning for these changes.

It is useful at this stage to focus on distance education which by its very nature, relies heavily on technology to support the educational process and to examine the impact of the new communication technologies on distance education.

DISTANCE EDUCATION

The history of distance education at the tertiary level in Australia extends over almost three quarters of a century with Queensland University offering external studies as far back as 1911 and the Royal Melbourne Institute of Technology doing so some eight years later. More recently the University of New England celebrated its Silver Jubilee in the field while in between these early and later events, some thirty odd publicly funded institutions have begun to offer external studies at the tertiary level.

Not only has the number of institutions increased but so also has the range of programs available including many of the sciences and professions both at graduate and undergraduate level as well as the more general programs in Arts, Commerce, Education and Social Sciences.

University and advanced education enrolments of external students, together with those at other levels, in both public and private institutions must now be approaching a hundred thousand. For a variety of reasons it can be expected that this mode of education will continue to increase in popularity.

These developments, in themselves, are not intrinsically relevant to satellite developments except insofar as they indicate a sizeable and growing aggregate of potential satellite users. The more basic question is whether or not present technology is meeting adequately the needs of distance education systems and, if it is not, whether a communication satellite will remedy the defects. In order to make such a judgement it is necessary to understand in broad outline the nature of distance education systems. It should be noted that in this paper the terms 'distance education', 'external studies' or 'off campus' studies are synonymous.

A distance education system (3) provides educational access for those who do not wish to or who are unable to attend classes on campus. It requires the development and production of self instructional learning materials. Distribution is usually by mail. Audio tapes are frequently used. Increasing use is being made of video programs available centrally or in regional centres. Weekend workshops and vacation schools are common as are periodic tutorials or laboratory sessions which may be either voluntary or compulsory. Telephone contact with tutors or other staff may be encouraged and in some instances, telephone tutorials are used regularly. In some systems there are networks of study centres with tutors appointed locally. Few specialist student services are accessible to the student at a distance and most advising or counselling is done by tutors or administrative staff. Most systems appear to be 'overloaded' and little provision seems to be made for systematic formal evaluation. Student wastage is commonly regarded as high.

Without adducing the evidence to support the case, the present writers would suggest that these systems, to a greater or lesser extent, suffer the following deficiencies:

- inadequate resources to develop properly designed and published self instructional materials
- insufficient interaction amongst external students themselves and between students and academic staff
- slow response times as, for example, in assignment turn-around
- too much reliance on a single medium, the printed word
- difficulties in providing continually updated and accurate information both to students and to staff
- problems in maintaining student motivation, identifying students at risk, and knowing whether students are still 'on course'
- inability to provide adequate support services for students within increasingly tighter financial constraints.

The question to which distance educators must address themselves is: does the new communication technology provide an effective and economically viable solution to such problems?

SATELLITES IN EDUCATION

A good many educational experiments using satellites have been reported in the literature over the last decade. While space is insufficient to do more than mention them, they clearly indicate that a considerable body of experience has been built up.

The Peacesat project directed by John Bystrom is well known and its use exemplified in a course on communication futures reported by King and Sanderson (4). Wilke (5) discusses Alaskan efforts over a decade to provide all its residents with access to telecommunications, and in particular, the ways in which the educational community in Alaska is delineating the role of satellites in making television an effective learning resource. At a more specific level, Hoehn and Givens (6) discuss the use of satellites in nursing education, using three different 'treatment' conditions, namely two way video, one way video with two way audio and videotape in which the programs include all the teaching material given by an instructor, together with questions from students and answers. Then there is the Appalachian Education Satellite Project which is concerned with a mountainous and sparsely populated region covering thirteen states including 397 counties and showing how courses delivered by satellite could be tailored to meet local needs. (7).

Reference is made by White and Kelabora (8) to the Communication Technology Project for Education and Culture developed in Indonesia in 1974 in which they discuss the communication medium most appropriate to education in that country. Mody (9) discusses the Indian Satellite Instructional TV Experiment in which a viewing audience of nearly a quarter of a million was distributed over some 2,300 receivers.

Because such experimental applications are often highly subsidised and because they have the appeal of novelty, care needs to be taken in generalising from them.

In concluding this section of the paper the point made earlier is underlined, namely that the technological progress now under discussion, is not simply more of the same but offers dramatically different options. As Grayson says:

> "An assumption which is often made in technical discussions is that a satellite is only an extension of existing communication links which will allow us merely to expand what we are already doing. This is untrue, especially in education. Various technologies, including projectors, recorders, radio and television, have been used in education for several decades. Experience with them, however, has been primarily intra-cultural. These technologies have limited coverage - a classroom, a school, a city or a region - and education that has been transmitted has been confined to limited areas, to populations which tend to be rather homogeneous.
>
> Broadcasting from space, however, can cover large areas of the world, and can encompass people of many different nations, languages and cultures." (10)

Despite its potential, however, the satellite is not a panacea for all the problems facing education today. As Grayson observes:

> "In spite of the optimism that permeates discussion of the use of satellites for education, and the potential benefits that can be derived through their use, communications satellites are not going to solve the educational problems of this world..." (11)

But one must add that if satellites are to solve any problems, it will only be because of detailed consideration and creative planning.

Given then, that we are on the threshold of potentially vast changes, what are the issues to which educators should be giving consideration?

POLICY AND PLANNING ISSUES

1. Shaping Communications Policy

It is labouring the obvious to stress that deciding what capabilities the satellite should have and how best to maximise their use, should be a joint exercise between government, commerce and industry, and users, especially the non commercial users.

At present, however, there is some anxiety that decisions about the Australian system will be taken on the basis of technology - what the system can do - and the market place - who is prepared to pay and how much - with continuing vital matters of public interest receiving, if not by deliberate intent, much less consideration. Time is short, and it is necessary that adequate consultative structures and action be instituted immediately.

There are more specific considerations including

- . number of channels to be provided
- . frequencies to be used
- . extent to which channels need to be dedicated or conversely, the extent to which they can be shared
- . whether charging for non commercial users will be at full, discounted, or even nominal rates
- . whether satellite capability should be audio, video or both
- . if video, whether one way or two way, and
- . the extent and nature of central controls

Obviously the factors that are relevant to these decisions are complex and some indeed are determined by international convention. Nonetheless, the decision on certain of these issues may result in changing user opportunities considerably.

If a non commercial user viewpoint were to be expressed on the above issues, it may run something like this:

> The non commercial user needs a one way video channel with a multiplicity of two way audio channels using frequencies which permit the use of low cost earth stations. Channels could be shared with other non commercial users and charges should be heavily discounted or nominal. Non commercial users would want to participate in developing such controls as are needed.

2. Guaranteeing Access

If the issues noted above are determined in the directions suggested, and if some capacity is reserved, from the beginning, for non commercial users, there remains the problem of guaranteeing continuing access to the system for those institutions that invest heavily in developing the educational and technical capacity to use the technology.

The problem is best illustrated by observing that when the non commercial user asks the satellite planner about access he is often answered in the affirmative. What is sometimes not made explicit is that the non commercial user is at the end of the queue and access has been assured, initially, only because the satellite has surplus capacity. As the paying customer requires more capacity, the non paying customer is squeezed out. Hence, the need to ensure that there is an allocation of capacity that is not subject to that pressure, competition for its use being restricted to the non commercial users.

Perhaps it is possible to conceive that of the capacity of the satellite, 80 per cent could be made available for commercial users and 20 per cent reserved for non commercial users

To warrant this continuing access implies producing programs in quantity, maintaining high quality and attracting a large viewing audience. To achieve these in the area of tertiary education suggests that enlightened planning and collaboration in sharing resources of all kinds will become a necessity. Geography will no longer be a major factor in selecting courses: quality will. If educational institutions do not rise to this challence, others will do so.

3. Determining Educational Needs

A fundamental issue is that of determining the educational needs of the consumer, selecting educational uses appropriate to satellite transmission, and identifying the controls that may be required.

The problem is that potential users of the satellite often do not agree on what they want. Indeed there is a danger that some segments of the population who currently receive no service will express modest needs because 'anything is better than nothing'.

Other potential users might be resistant to the technology in much the same way as many teachers preferred not to use audio visual equipment.

Yet others might see in satellite communication uses that are either not appropriate or are far too expensive. In spite of the problems implicit in these kinds of response there would probably be wide agreement on needs which the satellite has at least the capability of meeting. Among them are:

- greater variety of instructional materials
- greater access to self paced learning programs
- more rapid and accurate diagnosis of learning difficulties
- readier access to remedial or bridging programs
- providing information for potential students about the availability of programs
- increasing interaction between educational institutions and between those institutions and other organisations
- enhanced student-teacher interaction
- enhanced interaction amongst students

Probably it is true to suggest that existing technology could be used to solve most of the needs listed above. That this has not been done, results from many factors. Academic staff have, in general, had to 'pick up' expertise in this field - there has been no specific training - and have often been subject to conflicting priorities between immediate (on campus) and remote (off campus) problems. Support whether academic, as tutors and counsellors, or technical in the sense of media specialists of all types, has been limited. Delivery systems have been slow. Communications, whether by phone or mail, are relatively expensive.

All of these are, of course, directly related not to lack of goodwill, but to cost, and for this reason the question of cost in relation to satellite use will be further examined later in the paper.

Finally under this heading, a comment about controls. Clearly, there are many controls outside the ambit of educational institutions. Matters such as the location of satellites and earth stations and of the parameters within which they should operate; monitoring to ensure that prescribed parameters and procedures are observed; and the control of on-board systems in the satellite including those affecting position and attitude: these are all matters which require regulation.

There is, however, an entirely different set of controls required related to co-ordination and rationalisation on the one hand, and quality control of offerings on the other. Whilst educational institutions have always advocated internal control, technological changes as well as other forces point to the need for either external controls over a multiplicity of institutions or voluntary groups of institutions which may then impose their own controls on their members.

4. Economies of Scale

A reluctance on the part of educational institutions to use new technology has already been mentioned. Much of this reluctance is due to the established nature of distance education systems which provide for the development and delivery of courses by traditional means. When new technology appears it is often considered as an additional activity and therefore as an additional cost.

Clearly, the answer to this reluctance is to ensure that processes involving new technology replace processes now rendered less effective. In other words, the costs associated with new technology should be substituted for existing costs. Any increased cost, therefore, is more likely to be marginal and should be commensurate with the increased quality of the service.

The scenario to be drawn later in the paper will demonstrate such a substitution. Communication costs related to distance become less important with the satellite which is distance insensitive and where the economies depend on the aggregation of large numbers of users.

> "Technology is most economical when large audiences are involved; when the same materials can be used by many people; when the equipment is used almost continually; when the capital expenditures and initial investments can be distributed over a large base of users." (12)

This underlines a further point being made in this paper, namely, that in the tertiary education field no single institution in Australia operates on a scale to allow such economies. Collaboration is essential.

Generally the educational user of a communication satellite needs access to:

- one or more TV channels on a satellite
- a much larger number of audio channels
- an uplink transmitter to relay program material to the satellite
- a multiplicity of small earth stations for use by individuals or groups.

In costing such a system the first three may be regarded as central costs and the fourth as a local cost.

Hupe (13) has shown how these costs vary according to number of sites, number of courses, and numbers of students per course and in total. Reproduced here is part of his table, omitting the larger entries that would only be conceivable in a population many times more than that of Australia.

TABLE 1

CENTRAL COST

Number of Learners (Nationwide)		Satellite Cost per Learner/hour	Programming Cost per Learner/hour
In Total	Per Course	$	$
12	1	600.00	10,000.00
120	10	60.00	1,000.00
1,200	100	6.00	100.00
12,000	1,000	0.60	10.00
120,000	10,000	0.06	1.00

TABLE 2

LOCAL COST

Number of Learners		Local Cost Per Learner per hour
Per Site	Per Course	$
4	1	5.00
40	10	0.50
400	100	0.05

The actual figures are not important as hardware costs are continually reducing and programming costs continuing to rise. The relationships might also be simplistic but they serve to illustrate the point that it is the number of users that determines whether distribution by satellite is economical. In addition, there are other factors such as percentage utilisation which must be considered.

What is clear is that the production and distribution of teaching materials in distance education by satellite depends on economies of scale. These economies of scale can be achieved by institutions within a sector e.g. tertiary institutions collaborating in the joint preparation and use of programs thus distributing the cost over a wider student base. In addition, co-operation between the sectors - tertiary, secondary, primary, and indeed, technical and further education - could reduce costs by optimising the utilisation factor.

5. Resource Management

In the interests of optimising satellite use, institutions must come to terms with the need for rationalisation and co-ordination.

In another useful article, Hupe (14) discusses the use of broadcast satellites in education. He indicates that three broad criteria might determine the choice of a telecommunications system:

1. numbers of user locations;
2. geographic dispersion of locations
3. avaibility of local ground systems;

and gives examples showing that in some cases those criteria would lead to using the terrestrial system and in others would indicate use of the satellite.

He then goes on to discuss the impediments to using the broadcast satellite and identifies these as:

1. The need for understanding in educational and social services communities of the opportunities, the costs and the most efficient modes of use.
2. The institutional, sociological and attitudinal changes necessary to adopt profoundly new service delivery concepts.
3. The lack of regional and national management and co-ordinating institutions to aggregate the market and operations of the many interested individual educational and social service entities.

There is a growing trend in distance education to move away from the purely correspondence type of education. This involves providing learning materials in media other than print, notably audio and video and in trying to enhance opportunities for student-staff contact, and for contact between students themselves.

Direct broadcast of either audio or video programs developed by distance education institutions in Australia are rare. Most audio programs are distributed to students on audio cassettes. In the case of video, again cassettes are used but often distributed only to regional centres. The costs of dubbing and distributing tens of thousands of audio cassettes and many hundreds, if not thousands, of video cassettes annually, are very substantial. This situation is not confined to one institution but is true of many.

Even so, the student who is remote from a study centre cannot view the video and a student without access to a cassette player cannot listen to the audio tapes, and so programs necessarily have to be 'enrichment' rather than 'core learning'.

At the same time it may be suggested that a number of courses and programs covered by these institutions show considerable overlap, that is, the material and aims have many more important similarities than they do crucial differences. This suggests that a co-operative approach may provide a means of making distribution more effective and of allowing the content of such programs to be more 'core' than 'enrichment'.

OPTIONS AND SCENARIOS

In discussing the potential use of the satellite in distance education, this paper is frankly speculative. It stems from two convictions. Firstly, that the future belongs to electronic communications and that the printed word is, at least in distance education, limiting. Secondly, that the existing boundaries of educational institutions are no longer appropriate to the education of the future.

Options

The satellite presents distance educators with three broad options.

The satellite can be ignored with the consequence that uneconomical duplication, rising costs leading to reduced service, and increasing inefficiency because of dependence on an outdated technology, will make distance education an increasingly undesirable educational option.

A second option is to make token use of the satellite in, for example, providing by direct broadcast, programs now distributed on video cassette. This would leave the existing distance education systems substantially intact.

The third option is a total rethinking of communication and distribution in distance education and the development of a radically different system that eliminates existing deficiencies by an optimal use of new technologies.

Institutional Co-operation

From what has been said, it is clear that the new technology will only be used effectively by collaboration and co-operation between tertiary institutions.

Broadly, there are two areas in which such co-operation can be seen most clearly. In developing courses it is possible to see groups of academics drawn from different institutions pooling their specialities to develop and write new courses. Instructional designers, editors and graphic designers, can similarly be used on a co-operative basis. In this way courses could be developed drawing on the best expertise available. Improved communication technologies make it possible for academics working in this fashion to participate in team meetings extending beyond even national boundaries.

Similarly, a common delivery and support service can be offered by a group of institutions each providing support to students (from any of the institutions) in their own area.

However, these possibilities presume the maintenance of institutional boundaries. What is more to the point, is that students should be free to choose their courses and programs across a range of institutions. Naturally it is not being suggested that a degree or diploma program can be assembled from a complete smorgasbord of courses but rather that a system of concurrent enrolment can extend the range of educational opportunities open to the student. The obstacles to such a system are usually administrative rather than educational.

Such co-operation leads to a much more detailed scenario which illustrates some of the new technology available.

Teletext

In a distance education system the printed word is the major vehicle for learning materials. If such materials are produced in bound illustrated volumes, such as those published by the Open University at Milton Keynes or by Deakin University in Geelong, they are subject to the whole range of publishing processes. These include typing and retyping of drafts, editing, designing, typesetting, proof reading, paste up and printing. Warehousing and distribution costs are substantial. With even moderate wastage rates many of the materials distributed to students who subsequently discontinue represent a high cost to the institution. The costs involved in preparing and distributing the printed word are considerable.

Alternatives are available. Today the academic who writes can have his draft typed and scanned directly into computer memory. He corrects a computer print-out and the corrections are keyed in on a V.D.U. At the same time, codes for typesetting are inserted and the computer will photo typeset the material. Each page now has the specified format, headings, marginal comments, illustrations and copyright acknolwedgements.

The difference is that it will not now be printed but held in computer memory as teletext. It is conceded that for many first level courses the volume of such material may still be such as to require using a printed format for distribution. However for second and higher level courses in distance learning systems much of the teaching material specifically written for the course is more in the nature of a guidebook leading students through a range of educational materials and experiences.

Telecommunication

The student enrolled in a course is now ready to study. He has a small economical microprocessor linked to his TV set and linked by modem to his telephone. He dials his local study centre where a mini computer acts as a switching device accessing the main frame at the central campus. The student is able to call up his course material page by page and work through it! Should he require a facsimile, his copier will provide it. Much of the time he requires only making notes for revision or study.

Already the technology making such applications possible exists. It is becoming successively cheaper. Students undertaking a course over a period of years will be able to afford such equipment, the cost of which would be amortised over the length of the course.

Our student of the future can go a step further. At the end of his study period he may have a question he wishes to ask his tutor. Through his terminal he can convey his message to the tutor. His tutor can read his mail via his own terminal and can immediately send a return message. Again electronic mail is a reality and this is only an extension of it.

The 'Isolated' Student

What has been described applies to the student who lives within a local telephone call of a study centre. The satellite makes it possible for the remote student to enjoy the same privileges.

In similar vein, courses which use audio and video programs can have these broadcast by satellite. The video recorder will soon be familiar in most homes and allow such programs to be recorded for later study.

At Deakin University, the first of a new generation of courses will be offered experimentally in 1981. It is a Graduate Diploma in Computing. The home technology has already been developed. Each student will buy or lease a micro processor which he can connect to his TV set. A mini computer at the local study centre will be linked by landline to the main frame at Deakin. Students will be able to undertake a course of study in their own homes which a few years ago would not have been possible.

More importantly, however, it provides a model that can be used for other courses. With continued refinement and more widespread use, the cost of this technology could reduce dramatically.

Retraining and further Education

The scenario outlined has even more relevance when it is considered that a substantial and increasing proportion of educational effort in the future will be directed towards professional and technical upgrading. The students will already be in the workforce. Their initial training will have launched them on a career but continued professional recognition will require periodic educational refresher courses. For such students, the new age in telecommunications will make these programs efficient and effective.

CONCLUSION

The satellite offers the most isolated people in our community educational opportunities previously denied them. In conjunction with computer related technology, it will revolutionise communication. Many of the deficiences of existing distance education systems can be substantially remedied by the new technology. Distribution costs will not be substantially increased provided the technology is used as a substitute for outmoded operations.

Among the more critical issues for consideration at this time is the need for non commercial users to develop a mechanism through which they can identify common needs and special requirements as well as co-ordinating the development of joint submissions for using the satellite. User groups including educational users need to begin collarboating in exploiting the resources inherent in the new technology. Collaboration both within sectors and between sectors is essential for program development, providing adequate delivery and support and in achieving optimal utilisation through time sharing. Such collarboation is most essential within those segments of education, such as distance education, where the dependence on technology to support the educational process is even more critical.

It is the belief of the writers that the planned and proper use of satellite and computer related technology will actually enhance the educational experience of the student both by individualising and personalising it and by allowing students easier and more effective access to staff.

The performance of technology has not always realised its promise as exemplified in the teaching machines of two decades ago, few of which have survived other than as technical curiosities

Notwithstanding such failures, it is generally true that technology fails most often when understanding of its appropriate uses is inadquate; when insufficient attention is paid to the development of the necessary support and software systems; and when the users are not fully consulted about their needs.

The coming of the domestic communication satellite should be a catalyst which stimulates a complete rethinking of educational systems that have changed little over the period of greatest technological change in history.

> "The question, however, is: Is education and all those concerned with its development ready for satellites?" (15)

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THREE STRIKES AGAINST POTENTIAL USERS?

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Abstract

Experiences at the University of Hawaii attempting to establish telecommunications contact with North American scientists and universities suggest three main obstacles to such efforts: the ignorance of users, the apathy of others, and the cost. To overcome such problems a telecommunications consultant could be helpful, if the consultant possessed certain characteristics discussed in this report.

INTRODUCTION

Some people who might like to use telecommunications systems do not do so. They are deterred by a combination of ignorance, apathy and expense. First, a potential user's own lack of expertise means that he must find his own way through an unfamiliar new field, acquiring the technical and logistical information needed to establish his telecommunications system. Secondly, the apathy of others towards telecommunications means that he must do it by himself, unaided by his employer, coworkers or an experienced, informed advisor. Thirdly, expense can be a factor, too, pricing systems out of reach, at least for the time being, and discouraging the potential user, after initially learning the cost, from further inquiries into possible alternatives.

Each of these obstacles alone would pose difficulties; together they discourage many potential users, delaying the adoption of new telecommunications systems perhaps for years, with deleterious effects for the manufacturers and marketers of the system, for the users who might have benefitted from it, and ultimately, for the entire Pacific community.

These obstacles can be illustrated by the present situation at the University of Hawaii.

EXPERIENCES

The geographical isolation of Hawaii makes it difficult for students and faculty, as well as off-campus technicians and professionals, to keep up with latest developments. This is a problem for many fields, but it is particularly serious in rapidly changing scientific and high technology fields like aerospace, energy and communications: aside from a few happy exceptions such as astronomy and oceanography--in which our location provides some benefits--scholars at the University of Hawaii face a major disadvantage in competing with mainland scientists and universities. Modern telecommunications technology could do much to overcome this disadvantage, but cost is a major deterrent. Telephone, perhaps the most convenient all-around mode, rapidly becomes expensive if used extensively.

The difficulties confronting potential users can be illustrated by examples from my experience. Note that these difficulties are not due to lack of technology, but rather to lack or access to existing technology.

The oldest form of long-distance communication, writing letters, is of only limited utility, so for years I had been making an annual trip to the North American mainland, at my own expense. By 1978 however, this was becoming financially unbearable, so I began seeking other ways of maintaining contact with key informants and colleagues on the mainland.

The University of Hawaii had an experimental PLATO installation. Although computer message systems could be very useful for long-distance communications, the system here presented two major drawbacks. First, usage was very heavy. For access to a terminal I would have to compete with many other people: some were also utilizing the mainland contact but many were students doing homework assignments using the computers' local capabilities, but also tying up its long-distance capacities in the process. The second major drawback was that PLATO did not go to the two primary locations I wanted to reach--California and NY-Washington.

Another more versatile system was offered by the New Jersey Institute of Technology, whose Electronic Information Exchange System could connect me with any telephone computer terminal in the nation through regular telephone lines. Although I and many of my colleagues could arrange access to terminals, the question of who would pay the costs,

$65 a month plus $7 an hour Telenet fee, blocked utilization of this possibility.

Next I turned to PEACESAT, a radio system using an obsolete but still functioning satellite, the ATS-1. Most of the other cooperating terminals are on the small Pacific islands to the west of Hawaii, but there also is one terminal at Santa Cruz, California. PEACESAT services are offered free, on a time available basis, for educational and scientific purposes. The only cost to users would be regular long-distance telephone charges from Santa Cruz to the people I would be talking to.

During a trip to California, I looked for people who would participate in trans-Pacific discussions using PEACESAT, and coordinate the arrangements on the North American end. After the trip and more arrangements by telephone, we had two successful conferences via PEACESAT, the first exploring scientists' attitudes toward new communication techniques, and the second examining scientists' choices of new topics for medical research. Each discussion had about ten participants, half in Hawaii and the other half in California, including University professors, students, business men, NASA employees, state officials and physicians. They all said the discussions were worthwhile, but further discussions did not occur because I did not have a California coordinator available to arrange the time consuming preconference details of contacting potential participants, telling them where to meet, when, etc., and I had no more funds for making the arrangements myself, either in person or with long-distance telephone calls.

The success of these conferences encouraged me to attempt a more ambitious project: developing a low-cost link between a regularly scheduled class at the University of Hawaii and one in North America. My purpose was to demonstrate to faculty and administration that such a link was feasible and useful. There was no doubt that it was technologically possible--the challenge was to do it on a shoe string, without adequate support, and still show that it could be educationally and scientifically beneficial to have regular interchanges with leading scholars in other parts of the world.

A direct long-distance telephone connection between the two classrooms would be the simplest solution, but it would also be prohibitively expensive; $1500 for long-distance charges alone, and this would not include speaker phones or any other equipment or services. Therefore my original plan was to use PEACESAT between here and Santa Cruz,California, and then patch into a regular long-distance telephone call to southern California. However, various problems prevented use of PEACESAT, so I also explored other possibilities, ranging from radio to linkage through NASA Ames Research Center to alternate phone calls over someone's WATS line, the Federal Telephone Service, and even amateur radio. In addition to individuals and departments within the University, I also contacted a number of outside agencies, including the Army, Navy, Air Force, Federal Aviation Agency, National Weather Service, Civil Defense, congressmen, National Marine Fisheries, regional and national offices of the National Aeronautics and Space Aministration, State Department of Planning and Economic Development, and, of course, Hawaiian Telephone Company.

If all else failed, we could still have a duplicate set of prepared slides, and could mail tape recordings of each session. We ruled out video taping as being too obtrusive, because of previous unsatisfactory experiences with the services and operators at Northridge. Moreover, I wanted to keep things as simple as possible this first time, to minimize the cost and the possibilities of things going wrong.

The details of establishing this telecommunications link have been complicated; someone who has not experienced a similar situation would have difficulty understanding the problems which can arise. For example, I was trying to estimate the cost of the telephone link between two points in California: Northridge and Santa Cruz. I began by phoning directly to Los Angeles information, since this was a toll free number I would not have to pay for. The Los Angeles operator did not give me the information nor did she tell me who could, so I called the business office for the Northridge area. The first person to answer switched me to someone else, who seemed interested in giving me the information but said I would have to tell her the specific prefixes. I didn't have the Santa Cruz prefix so I asked her if she could find it for me, since I was calling from Hawaii. No, she said, she couldn't, but when I got the prefixes I could call back to get the charges. I explained to her that I only needed an estimate, not the exact amount, but to no avail. Not wanting to run up the toll charge further or to make additional long distance calls, I then tried the telephone company in Honolulu. After talking to four different people I finally got one who offered to get me the information. I didn't hear from her for the rest of the day so I again called the phone company in Los Angeles and was eventually switched to a person who did get me the information.

If I had realized at the beginning how difficult it would be to get this simple information over the phone, I would have walked over to the campus library and looked it up myself in a Los Angeles telephone directory. In fact, I had thought of doing this but I decided it would be simpler and faster to phone the telephone company.

DISCUSSION

These experiences confronting a would-be pioneer in telecommunication usage illustrate the three main obstacles mentioned at the beginning of this report: (1) user's lack of expertise, (2) apathy of large organizations toward an individual user's difficulties, and (3) high cost.

What can be done about these obstacles? Although the problems may be difficult, some corrective measures could be taken.

For instance, my ignorance of telecommunications forced me to spend a tremendous amount of time learning the hard, inefficient way: by trial and error, exploring blind alleys and perhaps overlooking alternatives that would have worked as well or better. This points to the need for a telecommunications consultant, a person whose mandate and skills are broad enough to provide practical assistance for projects like mine and people like me. The University of Hawaii lacks a permanent consultant on long range, multimodal telecommunications. Three elements should be noted.

First, the consultant should be permanent, or at least be around long enough so that he will be aware of the particular situation in this area. A person could be an expert on hardware and could know all about the telecommunications situation elsewhere, but for maximum helpfulness he must also be well acquainted with assets and liabilities of the particular locale he is working in. This may require a couple of years, but some organizations are hesitant to commit themselves for such a period, preferring a more cautious approach, year by year, or even for shorter periods. This may not give the consultant enough time to develop knowledge peculiar to this location.

The second requisite of a good consultant is that he be familiar with all telecommunications modes, not just one. This was one of the most frustrating aspects of my experience. Several people at the university had considerable experience with one or another mode, such as PEACESAT radio or the New Jersey based computer system, but these individuals, though willing to help, knew little about other possibilities outside their particular medium, and so were unable to give practical advice on blends of media or alternatives to their own. They could not tell which would be best for a particular job.

The third essential characteristic is long-distance experience. The consultant should be experienced with communications over considerable distances, say thousands of miles, so that he fully understands the problems involved. Thus, experience only with the more familiar media such as movies or television is not in itself sufficient. He or she must also have encountered such situations as having a studio full of participants waiting for a conference which took weeks to arrange, and then, when the hour arrives, get no response at all from the other terminal thousands of miles away; or, to make the connection but then have reception so poor that it is difficult to understand what the conferees are saying. My point here is that first hand experience with such frustrations would increase the consultant's sensitivity to users' concerns, in a manner analogous to the practice of requiring aircraft mechanics to fly in a plane they have just repaired. In short, a capable coordinator or consultant would have been a great help.

The lack of a coordinator is indicative of a second major obstacle, apathy. By this, I mean institutional apathy toward long distance telecommunications. The University does not believe that telecommunications is important, or important enough to pay money for a consultant and for WATS lines. I am not referring to the several concerned administrators at the department chairmen or dean level who have been very sympathetic and have encouraged me to proceed, have tried to find information for me, and so forth. But these interests and efforts so far remain primarily at the individual level, and individuals with good intentions were not enough to provide what was needed. Although higher level decision makers may be concerned about telecommunication, other considerations have received higher priority.

It should be noted that apathy about telecommunications is not restricted to the university: hints of it are also found within the telephone company. For example, it is difficult to believe that the Los Angeles supervisor I talked to could not have given me the approximate cost of calls to Santa Cruz. Such information was probably contained in the front of the Los Angeles telephone book. Furthermore, of the several phone company employees with whom I discussed the cost of linking the two classrooms, not one suggested that I could cut the cost considerably by hanging up after 5:00 p.m., when the rates dropped, and then simply redialing. The once a week course would begin at 4:20 p.m., PDT and continue to 7:00 p.m. so two hours of class could be at the lower, after-5:00 p.m. rate. I had to think of this possibility myself.

The third obstacle, certainly a basic one, is cost. In fact, the major challenge facing telecommunications during the next decade may be economic rather than technological: providing low cost access for individuals and groups who cannot now afford it. One helpful step would be to change the rate structure, reducing the charges for nonprofit educational and scientific institutions like universities.

CONCLUSION

While my own experiences have been as a member of the University of Hawaii, I suspect that similar problems exist in other schools, in other kinds of organizations, and in other countries. Potential users in many settings may find they have three strikes against them, effectively putting them out of the telecommunications game. Unfortunately we may lose more than just a game, because telecommunications can do much to improve science and education, and ultimately the lives, of people in the Pacific.

Satellites for Public Service--Barriers to Technology Transfer

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Abstract

In the United States, experimental communications satellites have provided opportunities to demonstrate the potential benefits which space communications can offer in extending the range and expanding the roles of programs in education, health care and other public services. The transition from experiment to established operational status is often difficult. Many of the barriers are not directly related to space or communications technology, but to the organizational, economic and human factors which tend to inhibit public service organizations from internalizing major changes in their behavior.

1. INTRODUCTION

During the past ten years in the United States, the experimental Applications Technology Satellites, ATS-1, -3 and -6, and the joint U.S.-Canadian venture, the Communications Technology Satellite (called by our Canadian colleagues "Hermes") have provided a large number of interested entities in education, health care, and other public services with opportunities to explore, on a first-hand basis, the ways in which space communications can assist in expanding the reach and advancing the goals of public service efforts.

Communications satellites, being distance-insensitive, have allowed us to reach groups beyond the practical or economic reach of conventional communications. We have seen that the technology can provide small, inexpensive, and simple earth stations which can be operated and maintained by ordinary persons without advance technical training. The flexibility of satellite communications has permitted us to add, subtract or reconfigure the network of communications nodes both quickly and inexpensively. Where the systems have been able to provide television communications, they have readily accommodated other services, such as voice, data and facsimile, as well. Since satellites can provide "instant communications," it has been possible to implement wide-spread and complex services on a timely basis.

We have seen how communications satellites can be applied to extending important public services to rural and sometimes isolated communities, an important matter in a society which holds that all citizens, regardless of location, should have equitable access to education and health care. We have demonstrated that satellites can be equally beneficial in linking what, to borrow a phrase from Robert Boyle, we may term "invisible colleges," those communities of interest which, while their members may be geographically disbursed, are strongly linked by shared professional, business or ethnic concerns. One family of such invisible colleges can be seen in the rapidly growing importance of continuing professional education: Engineers, lawyers, teacher, health care professionals, and many other such groups are under growing internal and external pressures to change "lifelong learning" from a pious platitude to a necessary practice. Satellites have shown their value, not only for linking distant university campuses, but for bringing continuing education to practitioners in the field.

Such experience has been of great value, and practitioners in public service fields are, to a growing degree, beginning to translate the knowledge gained from ATS-1, ATS-3, ATS-6 and CTS into on-going operational services using the established commercial domestic communications satellites in the United States. But this is not universally so, and it is important to note that there are significant barriers to such technology transfer, not all of them technical.

2. TECHNICAL BARRIERS

Some of the roadblocks which prevent the transition from experimental to operational status are, undeniably, technical in nature. Each of NASA's experimental communications satellites has been designed to push forward the state of the art, but not all of the scientific and engineering accomplishments demonstrated have yet found their way into the marketplace. ATS-6 provided experimenters in Alaska, the Rocky Mountain states and in rural Appalachia with a communications system operating in the 2.5 GHz band and using earth stations with 3-meter antennas. The end of ATS-6's life left these experimenters with no equivalent follow-on and with terrestrial infrastructure which, to be used at all, will have to undergo conversion to the 4 GHz band in which the available commercial satellites operate.

The experiments on the Communications Technology Satellite helped to demonstrate the technical viability of CTS's 20- and 200-watt transponders, but U.S. experimenters are now left with a family of earth stations tuned to a frequency band which is not currently in use. In time to come, Satellite Business Systems' proposed system and Advance Westar will provide new space segments operating in the Ku band, but those operations are planned to be digital, not analog. It should be noted that, for our Canadian colleagues, the situation is different, since the Department of Communications has arranged with Telesat Canada that Anik B include transponders at 12 and 14 GHz which can provide the basis for follow-on to the important work which was begun on Hermes (CTS).

The most dramatic example is to be found here in the Pacific where a number of important experiments, including the "Peacesat" program and the work of the University of the South Pacific's link-up of its multinational teaching centers has been accomplished through use of the narrowband VHF transponder on ATS-1. Originally designed for an experiment in air-to-ground communications for planes in transoceanic flight, the satellite proved its worth in that regard more than a dozen years ago. Voice and facsimile communications among some of the poorest, smallest and most isolated nations on the globe is a happy afterthought, but translating these experimental networks into operational terms will face the imposing difficulty that no equivalent follow-on to ATS-1 and -3 can be reasonably anticipated and that the frequencies used are allocated for aircraft communications and thus out of band for any regularized service.

Despite such handicaps, the transition from experimental to operational service is being made in a substantial number of cases. Uniquely, the State of Alaska, with its extensive satellite network employing the RCA Satcom system, has been able to put into practice some of the most important lessons in education, health care and social services learned from the state's experiences with ATS-6. In Appalachia, the Appalachian Regional Commission, a public agency which has both Federal and state government participation, has formed the Appalachian Community Service Network and plans to extend and expand upon the teacher education and other services pioneered on ATS-6 by leasing time on two RCA Satcom satellites and using the growing number of interconnected cable television systems as the vehicle for the delivery of educational services. A number of other public service organizations, many new to satellite communications, are being helped to enter the real world of common carriers in space by non-profit Public Service Satellite Consortium whose National Satellite Network is not so much a network in the conventional meaning of the term but a service which can bring together users and suppliers in whatever configuration is most appropriate to the task at hand and most likely to achieve effective results at affordable costs.

3. NON-TECHNICAL BARRIERS

But the technical considerations, while they may be the most obvious, are not always the most critical. Questions of economics, organizational dynamics, and "people problems" may not always be visible, but they are always important.

Those in government most directly involved in the support of the development of satellite communications for public service purposes, the National Aeronautics and Space Administration and the Department of Commerce's National Telecommunications and Information Administration, are aware of, and attentive to, these non-technological barriers to technology transfer. NASA's born again research and development activities in space communications will address the seeking of solutions to the needs of those, such as residents of rural areas and members of countless "invisible colleges," whose needs are for thin route communications where traffic may be only occasional but is often, as in emergencies, critical. NASA's efforts to demonstrate more efficient ways of using our common frequency and orbital recources may be anticipated to open up new opportunities for communications to and within highly targeted areas and audiences.

NTIA is also addressing such needs as those of expanding the user services provided by noncommercial broadcasting and assessing the uses of advanced technology in providing public telecommunications services. The application of space communications is specifically included in the list of NTIA's concerns, and an Interagency Committee on Satellite Telecommunications Applications, chaired by NTIA and including NASA and a wide span of other Federal agencies, is responding to a Presidential review of national space policy which concluded that the public service sector in all areas of the country, and particularly in remote and rural areas, has lagged behind in the recent expansion of the commercial use of communications satellites.

As part of the U.S. Civil Space Policy Review, President Carter charged NTIA with responsibility for leadership in the aggregation of the public service satellite market, and the Interagency Committee is serving as a vehicle by which member Federal agencies are attempting to evaluate their requirements and cost out their integration into an aggregate system which could include the widest possible family of public service users.

The problems of market aggregation illustrate a number of the non-technological barriers to intergrating satellite communications into public service activities. In 1976, Robert K. Yin and others at the Rand Corporation produced for the National Science Foundation A Review of Cast Studies of Technological Innovations in State and Local Services. Yin and his colleagues examined each of 140 cases with regard to the characteristics of the technology, the characteristics of the organizations, and the implementation strategies employed. Comparing the organizational contexts, it became clear that centralized authority promotes technical innovation. Satellite Business Systems, in designing an expensive and complex system for the very cream of the Fortune 500, would appear to give recognition to the same principle. For most of the public service community, however, centralized authority is notable by its absence. There are some 2500 colleges and universities in the United States, and although some are units in intra-state systems, even there the strong academic traditions of local autonomy extend even to the individual professor in his classroom. Some years back, the financial community witnessed the birth of "the education industry" when major companies in film and broadcasting merged with publishers of textbooks and manufacturers of learning aids in search of the rich veins to be mined in the education-information field, said to be the most rapidly growing sector of the American economy. Their dreams shattered on the hard reality that, while billions are spent in the education of America's children, they are spent, often only a few dollars at a time, by the teachers, principals and administrators of some 20,000 independent school districts, and "independent" is the operational word.

Education provides a fair sample of the public service "market" and similar pictures could be painted in health care, social services, and other public service areas. To make the matter still more difficult, aggregation to the levels necessary to achieve required economies of scale will clearly require bringing together formerly unrelated and already disaggregated groups. Hospital administrators do not think of themselves as hospital administrators; while they may talk with the local superintendent of schools about the football season or the cost of gasoline, they will have to be coaxed into comparing communications needs and exploring the possibilites of identifying and solving problems which they do not yet recognize as common to them both.

Yin and associates discovered that "hardware" innovations are more likely to be adopted than such changes as improved computer software and that "transitive" devices--those which assist in the delivery of services to end users--took root more readily than those which merely contributed to administrative tasks. Our experience with satellites to date gives reason to believe that space hardware can be successfully applied to improving service delivery, often with spectacular results, but that facts alone will not overcome other barriers.

The closer the technology comes to the service recipient, the more do we deal with those to whom new technology may appear strange and threatening. Often those whose enthusiasm for technology exceeds their understanding promise too much. Those with pressing problems may seize upon the satellite, or the computer, or synthetic fuels as the miracle cure, and when no miracles occur, and when problems are not cured, but only relieved, disillusion creates back-lash.

The very technology, itself, can be an intrusive factor, and training and familiarization activities may be needed before those who are to use it can do so and feel comfortable with new hardware and procedures. Mastering a video teleconferencing system requires the acquisition of at least a few new skills. Video systems based upon the use of cameras and facilities designed for broadcast may require broadcast technicians to run them, but then a new intrusion, the presence of "strangers," may then become a factor. Sometimes the additional personnel costs for those required to man or maintain the system are insufficiently anticipated in initial estimates of costs and potential benefits.

Measures of true cost effectiveness, or even cost/benefits, are not easy to come by in the public service area. Unlike much of business and industry in which there are tangible products and/or processes, quantifiable data are often hard to find. Satellite communications may permit the doctor to see more patients per month than was previously possible, but is their health care improved? And by how much? Is "something" (the "personal touch"?) lost in the process?

Before the first satellite was launched, television found its way into the university classroom, often to extend the talents of a single professor to a larger number of students. While evidence could be adduced, at least in some cases, that student learning was the same as in the conventional classes, many argued that test scores and measures of comprehension could not provide all the data on true "learning" as it is presumed to take place in the regular classroom. But what such other unmeasured--perhaps unmeasureable--ingredients might be, no one could quite define, nor if we could ascertain their value in a technology-based situation, would we have measurements from the "old way" with which to compare.

Environmental problems may also be present in the human terms of those who are expected to use the system. If the hardware is only available at certain locations, as with teleconferencing, or computer-assisted instruction, or facsimile transmission, then the very process of having to leave a familiar working environment to accomodate to the technology could exact psychological penalties which may be exacerbated if the new location is in the domain of a different agency or working group. Finally, if the "transportation barriers" are high enough, the user may consider the supposed advantages not worth the price. "If I have to go to all the trouble of taking a taxicab across town in rush hour, I'd just as soon fly to Chicago for a face-to-face meeting!"

Other unanticipated psychological effects may be introduced. A medical communications system which allows continuous two-way contact between the doctor in the hospital and the nurse-practitioner at a distant health care unit may be designed to provide the nurse a readily available source of assistance when she needs it; the doctor is available at her beck and call. But so is she constantly available at his, and her independence is diminished. A system that gives her help whenever she needs it may be seen by the nurse--and/or her patients--to imply that she needs it often.

Satellite technology--at least that of the present generatión of commercial domestic satellites available to potential users in the public service community--makes easy the implementation of asymetrical networks, with video from one point (preferably a major city at which the carrier maintains up-link facilities) to many and, if needed, return narrow band communications, such as voiced questions, by telephone. Such a configuration may be highly desirable in presenting a televised lecture or seminar, but not so useful where there is to be an exchange of information among peers at each of the locations. How public service users employ satellite communications may well be shaped by the systems architecture.

On the other hand, systems like those proposed by Satellite Business Systems and Xerox for business users, and such future technology as may result from NASA's further research and development, are likely to result in space communications better suited to "star" networks. The implications for public services in the United States, where decision-making and action authority are already disbursed, may be highly significant. The experience of the National Education Association, which ran a series of seminars on ATS-1 for teachers in rural Alaska and included teachers in the Pacific as well, quickly revealed that the teacher participants were not interested in hearing from the "experts" in Washington, but from their colleagues in other one-room schoolhouses whose first-hand experience in meeting common problems could be applied to their immediate needs. Fortunately, ATS-1's narrowband VHF transponder, acting like a giant "party line" lent itself well to such conferencing.

The economic structure of most public service agencies tends to work against the introduction of technological innovation. While industrial corporations may consider that 5% of the yearly corporate budget a minimum investment in research and development, few public service agencies have any discretionary funds at all. In the Federal agencies, and in many state, local and private agencies as well, there is a trend toward Zero Base Budgeting under which each activity and program must justify its existence. With too few dollars to do whatever the job may be, monies invested in technology which is inherently expensive are seen too often as being monies diverted from hiring additional staff, raising salaries, or otherwise reducing an established list of long needed improvements on which telecommunications, as such, is unlikely to have a very high ranking.

Perhaps most important is the fact that those who decide, those who benefit, and those who pay are often, in the public service community, entirely separate groups and the communication and decision-making linkages among them may be sparse. Some hypothetical examples:

Telecommunications as a substitute for travel is an oft-suggested trade-off and, as fuel prices in the United States more nearly approach world levels, such substitution may appear increasingly attractive--to those who control the budgets. To the some would-be travelers, substituting a teleconference for several days away from the office routine and a comfortable trip at agency expense may seem a poor trade, indeed. Conversely, at one recent conference a government employee noted that the monthly rental charge for a facsimile telecopier approximates his costs in driving to his government office. His suggestion: that the government rent him a telecopier so he could work at home. The money spent (by the government) would exactly "balance" the money saved (by the employee). He was serious.

Dr. John Carey, of New York University's Alternate Media Center, raises the question of need--and who recognizes the need--and cites the case of a health project for Native Americans in which the Indian Health Service, a Federal agency, perceived the need for telecommunications, and the Indians saw the need, but, according to Carey, the health care deliverers, the doctors, were unconvinced.

Because of such factors as these, implementation often takes longer than planned. To the engineer, the implementation time is that required to put the system in place and to "de-bug" it; to the boss, it is the time to get the system on line and available for use; but to the users, a first use or a second use cannot be equated with true implementation. New technology has to be assimilated until, like the telephone, it becomes an unobtrusive part of the normal way of doing business.

Yin's Rand study suggests that there are two separable innovation processes, one having to do with improvements in productivity of service delivery, the other involving bureaucratic self-interest. As may already be apparent from some of the examples above, or from personal experience, innovations which can help promote the growth, status and power of the organization and those within it are likely to be adopted. The reasons include the facts that public service organizations realize their income through the budget review process, rather than thrôugh the market mechanism which is more likely to provide direct rewards for increased productivity.

4. CONCLUSIONS

If technology transfer is to be accomplished in bringing satellite communications' demonstrated benefits to the public service sector, true "systems engineering" will have to extend beyond analysis of the hardware components and incorporate consideration of all of the open and hidden agendas of the agencies and the people who staff them. Overwhelming evidence indicates that innovations paid for by external (e.g. Federal or foundation) funds are all too likely to expire when outside funding ends. To get public service agencies to adopt and support innovations from their own resources and within their own self-ordered priorities requires a process which is as much a matter of policies and politics as of technology and terminals, and it will be well to include planning for eventual adoption, maturity and continuing viability at the earliest stages of conception.

Participants will have to move through four processes: understanding, problem indentification and planning. As the National Aeronautics and Space Administration develops plans for research and development activities consonant with the new U.S. Civil Space Policy and as the National Telecommunications and Information Administration provides its support of improved rural and public service communications, the potential beneficiaries in the public sector and those whom *they* serve will need to join together in ways in which their iterative contributions can result, not only in new technology, but in new technology transfer. Groups like the Public Service Satellite consortium and our own Joint Council on Educational Telecommunications (a founding member of the Consortium) can help to build the bridges which will be necessary to get the job done.

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Experiment and Change in New Zealand Broadcasting

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Abstract

Broadcasting in New Zealand has recently gone through excessive paroxysms of change. Lessons from this experience could offer valuable insights into the various alternatives suggested and practiced for the structuring of a communications system: its philosophy, its form, its governance, its personnel. Furthermore, New Zealand offers a rewarding example of the problems of government involvement in communications, and of the viable and all-important role to be played by the individuals charged to administer the resultant system.

1. INTRODUCTION

In October, 1980, the Broadcasting Corporation of New Zealand announced a restructuring of its executive control in television. Six months earlier, there was a more substantive change when the Corporation's monopolistic television service abandoned a system of two competing networks to establish two channels operated by a single agency which will offer a complementary service. Such dramatic upheaval in the country's broadcasting system is not unusual; change has proven to be the essence of the New Zealand experience. Indeed, the most recent history shows four reorganizational moves in as many years (1). Each gave a radically different broadcasting structure with its own concepts of regulation, control, administration, and government involvement.

In that this New Zealand experience differs widely from the relative stability of broadcasting systems in other parts of the world, the causes and effects of such incessant change are of relevance to those with interests in the policy making, regulation, and control of any communication system.

2. HISTORY

2.1 EARLY DAYS

After an initial experimentation with a private radio company and its replacement with a public Board, a pattern of continuity was ensured by a Labour government which placed broadcasting firmly in the hands of government with the establishment of the National Broadcasting Service (2). Not only was the new government department given monopolistic rights, but also for the first time in any democracy, a special cabinet rank of Minister of Broadcasting was established.

This early direct involvement of government in the nation's broadcasting operations was to set a continuing pattern and a mental attitude that--despite the various name changes--still persists today. Government feels that it has a right to influence directly broadcasting; broadcasters are used to such a relationship; and politicians are looked to by the public for accountability in broadcasting matters. It may not be the most endearing environment for the free flow of ideas and information, but it is the New Zealand reality.

Despite the questionable role of being a department of state, it was during this period of more than two decades that broadcasting enjoyed its greatest stability and its greatest respect as a public institution (3). Two events occured in 1960 to threaten this tranquility. The introduction of television presented the not uncommon problem of a relatively small population coping with large capital expenditure. This thrust broadcasting into the centre rings of public awareness and political concern. In the same year, on the political front the Labour Party's lengthy term in office came to an end with the triumph of the National Party and of its philosophy to contain the limits of socialism.

2.2 NEW GOVERNMENT: NEW CHANGE

One of the first moves of the new government was to offer the semblance of removing broadcasting from direct government association by establishing the supposedly independent New Zealand Broadcasting Corporation. However, it is unrealistic to suppose that this legislative maneuver made any significant difference (4). At the political level, the Minister of Broadcasting portfolio was retained, government assumed responsibility for the all-important financial aspects of broadcasting, the senior executives of public service days were transferred to the new public corporation along with their ingrained public service mentality, and the politicians and the public both continued to see parliament as the final arbitrator on all broadcasting matters (5). As far as the broadcasting service was concerned, the new Corporation merely took over the NZBS's monopolistic position, which it jealously maintained through the legislative provision which made the Corporation responsible for evaluating and recommending on any competing system.

The change of status to a public corporation at this time did signify one important aspect: it was the first example of an ugly New Zealand characteristic. Radio, television, and the subsequent systems of control have become one of the country's major political footballs. At every change of government there have been wrenching changes in broadcasting.

The political to-and-froing of the parties in power in recent years is the major cause of the constant disruption in the then prevailing broadcasting pattern. Even the threat of an imminent election has been enough to encourage the government to propose changes to the system if it is returned to power.

The first such tinkering did occur with the National Party being returned to office. Fulfilling an election promise, it established the New Zealand Broadcasting Authority in 1968. The intent was to resolve the dichotomy whereby the Corporation was both judge an jury for applications from competitors for the broadcasting scene; a matter which came to a head when pirate radio stations started broadcasting from outside New Zealand's territorial waters.

The Authority was to assume total responsibility for advising the Minister on licensing matters for both the Corporation and a now possible private sector. It could have been a dramatic change. But the new body lacked direction, leadership, and broadcasting experience (6). The consequence was a weak body with generally inept decisions, apart from their major accomplishment of introducing private radio stations to serve local communities.

3. THE EARLY '70s

3.1 LABOUR'S DRAMATIC UPHEAVAL

The return of a Labour government in 1973 promised conserted political intervention. One of the first public announcements of the new Prime Minister concerned the introduction of a second television channel. Although the supposedly independent Authority had already conducted lengthy hearings on the matter and was preparing its report, the Prime Minister lept into the fray with the unsurprising announcement that the Corporation would maintain a television monopoly by operating the second channel. Ironically, the Authority was later to issue its report which concluded that a private company might well be licensed to offer the alternate service (7). However, the days of the Authority were clearly numbered.

Despite the fact that change of government in New Zealand automatically cues a response in broadcasting terms, nobody was prepared for the startling proposals that were suddenly forthcoming from the Labour government (8) The NZBC was to be dismembered and its functions transferred to three separate broadcasting bodies: one for radio, one for the then existing nation-wide television service, and one for the new second television channel.

The Authority was to be replaced by a Broadcasting Council. It was given similar charges, but was to include representation from the three new corporations. Further provisions excluded the extension of the private sector. A surprising element from a Labour government was the abandonment of the Minister of Broadcasting portfolio.

To bring detail to its ideas, the government appointed the Adam Committee on Broadcasting. Because this Committee is sometimes blamed for most of the consequences of the resultant restructuring, it seems fair to point out that this was not a traditional broadcasting committee which is given an open hand to investigate and report on a nation's broadcasting system. The Adam Committee had a very limited charge: it was to flesh out an already announced government plan to establish the new structure.

With this 1973 development, New Zealand became the first country--in what was to become a popular global trend--to restructure its monolythic, centralized public broadcasting services along pluralistic, regional, competitive lines. As this system was subsequently rejected, the trials, tribulations, and failures of the New Zealand experience are worthy of investigation.

3.2 ORGANIZATIONAL PROBLEMS

As might be expected, the ultimate rejection of this new intiative was politically motivated. The National opposition made it clear that if it was to be returned to office it would abandon the new system. That was not an encouraging beginning; and it proved the subsequent end. National became the government in 1975. By 1976, the Broadcasting Council had vanished.

Yet there were inherent weaknesses in the tripartite system. These, in themselves, meant that the system could not survive long under any political climate.

Such a structure places excessive reliance on bureaucracy. Three broadcasting corporations, independent of each other, necessitated three Directors General at the very top, and a triplication in administrative support. This proved an unsurmountable burden in a small country which found itself with too few people adequately trained to assume such responsibilities.

Contributing to the resultant poor management was the innovative decision--that was subsequently to prove ill-conceived--of filling top administrative posts with individuals whose previous broadcasting experiences were in production. This was one error that can be laid at the feet of the Adam Committee. They had strongly advocated giving the dominant role to creative personnel (9). The two areas where the new television services proved particularly weak were in programming and in finance; those two areas which most other broadcasting bodies consider paramount for success. Financial matters were not made any easier by the government's calling for the introduction of color transmission at the same time as introducing the second service. The two televison corporations never surfaced from the huge deficits involved in the borrowing from government to finance the requisite capital outlays.

Furthermore, the calls for a quantum leap in high-level personnel meant that the new services were staffed with very young and relatively inexperienced individuals. Not only was it a problem for the day, but also the public service nature of employment in New Zealand broadcasting means that senior positions are held by staff members entrenched in decades of future work.

3.3 IDEALISM VERSUS PRAGMATISM IN PROGRAMMING

One of the great plusses of the restructuring was the renaissance in radio. Given a status and a reliance independent of its more glamorous rival, television, public radio expanded, flourished, and achieved a great degree of public awareness and respectability (10).

The two television services were not so lucky. While it is unquestionable that they challenged the complacency of the monopolistic telecasting that had become the established tradition of the former Corporation, they did so with a vigor that was to spell their downfall.

The original intent, as outlined by the Adam Committee, was to create a climate for "guided competition" (11). The Report made it quite clear that the Council was to assume final responsibility for the delicate balance between complementary yet competitive programming (12). However, the same Report, in over-emphasizing the decentralized regional nature of the new system, established a very weak council (13). Subsequent failure was to be expected.

The end result saw all of the emphasis on the competitive rather than the complementary element (14). The situation has been well summarized by New Zealand academic James Richie: "The competitive-complementary formula resulted in the two channels watching one another more than either their audiences or their own screens. . . It is cynically accurate to assess that this is what the two channel decision was all about, doubling the advertising revenue, doubling the consumer needs for sets, serving industry rather than the public" (15).

There was public discontent; and so very little outcry when the National government of 1976 once more went about restructuring the system

4. RECENT DEVELOPMENTS

4.1 NATIONAL'S TURN

Initially, the new government simply replaced the weak Council with a return to the stronger corporate model in the new Broadcasting Corporation of New Zealand. The three independent broadcasting bodies now became three separate services run by the Corporation. Political authority was clearly reaffirmed with a return to a Minister of Broadcasting; and the prospect for future competition for the public sector was introduced once more with the reestablishment of a separate licensing and complaints authority: the Broadcasting Tribunal.

These changes could have been merely cosmetic. The effect of them has been the consequence of intelligent appointments rather than in the establishment of any bold and innovative structure.

The Tribunal has seen its charge as that of vigorous watchdog of the existing mixed system, dominated by a to-be-cherished and therefore protected public sector, but with room for private elements when they exploit broadcasting's capability for diversity. As such, it has astutely avoided any smear of being associated with political favoritism for National Party private enterprise, and has brashly asserted its independence. The decisions have been well reasoned and well received. The Tribunal has displayed a commitment to being a major force on the New Zealand broadcasting scene.

The Corporation achieved initial acceptance with the appointment as Chairman of a national sporting hero who had also managed to achieve financial success through his business acumen. This latter fact brought welcome monetary concern to broadcasting decision-making.

The untimely death of this new Chairman involved the government in finding a replacement. In the choice of Ian Cross, the National government have, perhaps inadvertently, totally changed the face of the country's broadcasting.

There is a danger in assuming that an understanding of the structure of a communications system permits an accurate analysis of its functioning. The current New Zealand example shows that while the system has remained basically the one established in 1976, Mr Cross's assumption of the Chairmanship has, in itself, brought as much change as the Labour Party's radical restructuring of 1973.

4.2 THE FULL-TIME CHAIRMAN

Firstly, in an unprecedented move in New Zealand broadcasting, the Chairman of the Corporation has become a full-time salaried position. This was mainly because Mr Cross lacked independent means, yet the government saw him as the best candidate. From this accident of history, rather than from any passionate philosophical concern, a dynamically new role for the Chairman has emerged. In effect, the Chairman of the Corporation has become the chief broadcasting executive. Gone are the days when the functioning of the governing board and its chairman were limited by concerns for policy and guidance for finance and service.

Today, the full-time Chairman has become actively involved in programming and in administration. In addition, he has been the vociferous champion of broadcasting and its most ardent advocate for reform. For the first time in many years, New

Zealand broadcasting is offered forceful leadership. It is an interesting development in that the best-reasoned criticism of the Adam Committee report argued that broadcasting's success lay not in the advocacy of competition, but in good leadership (17).

At the simplistic level, the new role taken by the Chairman can be seen as a return to the earlier NZBC structure; a single executive assuming responsibility for all broadcasting matters. The terms "Chairman" and "Director General" become meaningless. The National government have firmly established a broadcasting "czar," and this is the Chairman of the Corporation.

While this may be seen as a dangerous situation by those who prefer a diffusion of power and its removal from government influence, the realities of the moment point to the ultimate success of this structure because of the individuals involved.

Fears of a return to Ministerial power involving excessive government interference ignore the fact that the present Minister has a strong commitment to the Corporation's independence. He sees his role as one of positive assistance and of assuming, as an elected rather than an appointed representative, responsibility for the important social institution of broadcasting (18). The politician who has actually had the most direct involvement in broadcasting is the Prime Minister (19); a situation that could obtain under any circumstances.

It might well be contended that the Minister shares an unhealthy covert relationship with his appointee, the Chairman of the Corporation. While the present situation may look as though one is influenced by the other, this is more because the Minister and the Chairman are very much alike as individuals. They are both relatively liberal thinkers with open minds; they are men with a passionate commitment which they temper with a degree of intelligence rare to New Zealand. They share many common beliefs. While there are frequent exchanges, it would be difficult to ascertain who influences whom. Actually Mr Cross has established an almost vitriolic record of political independence; not being afraid to defend himself, his office, and the broadcasting system from what he considers unwarranted political attack (20).

4.3 THE NEW SYSTEM

Mr. Cross has replaced his predecessor's concern with finance with one for programming. Ever since assuming office, his main attention has been given to redressing the adverse effects of the outright competition in television. At his suggestion, the government amended its 1976 legislation so as to abandon the separation of the two services and establish a single body charged with programming two separate channels. A direct about-face is called for. The thrust is to be complementary and not competing. Scheduling decisions are removed from two separate entities and are given to a single centralized authority (21). Once more, this places New Zealand to the forefront. The degree of complementary programming undertaken by the newly restructured corporation would horrify those trained to program in a competitive environment. Like versus like programming has been astutely avoided. There has also been the total abandonment of the patronizing stance taken by other broadcasters faced with a similar situation: news must compete against the most frivolous of light entertainment; local programming against the gloss of the imported product. Of all peoples, the New Zealand television viewer with just two channels is now in the best position to make a real chice. It is a great risk of faith in both the quality of local production and the quality of the audience.

Coupled with this is a commitment that regionalism will be part of this complementary mix. Those who remember New Zealand television of fifteen years ago will see another turning back of the clock: a reliance on local production centres to give a distinctive regional flavor to the national service, and, more importantly, some local programming.

The 180 degree turn whereby the present structure recalls the days of the NZBC has been reinforced by the more recent decision to have television operations under a single administrator rather than persisting with the clumsy bimodal structure based on the unclear distinction between production and programming. This had been a remnant of the unfortunate predicament of having two Directors General on hand after the earlier 1980 restructuring.

However, the consequence of having the new Director General in the largest population centre of Auckland, while keeping television's major production facility and the Corporation in the political capital, Wellington, have yet to be evaluated. They do not augur well for the future.

5. CONCLUSIONS

The New Zealand experiment in a pluralistic decentralized public system of broadcasting did not prove satisfactory. Apart from the fact that the ever-present political rivalry between the two major political parties would assure that the experiment would not be continued with a change of government, there were enough inherent problems to assure a continual decay and ultimate restructuring: an excessive bureaucracy for which there was an inadequate supply of well trained personnel; an expensive duplication of facilities and services; and a philosophy of competition which, when unrestricted, would dominate decision-making.

These were coupled with a naive reliance on creative personnel for seniot executive positions. As such there was sore neglect of equally important aspects of broadcasting: programming and finance.

The trend in New Zealand has, therefore, been towards a return to a greater degree of centralization, a consolidation of power, traditional lines of administrative control, and attention to money and scheduling matters. These have been mollified with a commitment to local programming. But the overall impression for the noble experiment is that national communication systems probably function more effectively and efficiently with the removal of disparate and conflicting elements, and with concentration in a single, well-structured, and competently administered unit.

Yet the current situation--which does have hope of success-is hardly assured continuity. A major problem for New Zealand is the extent to which broadcasting is a major concern for new governments. Whenever there is a change at the Treasury Benches, it is assumed that there must be a display of muscle in the restructuring of the broadcasting system. No system can hope to develop fruitfully under such a constraint. The constant change has led to perennial morale problems amongst broadcast professionals, and much justifiable criticism from the public.

Over the years, New Zealand has clearly resolved the issue as to whether political or commercial interests should dominate in broadcasting matters by opting for the former. It has not adequately addressed the fact that the final responsibility is to the people. Persistent political meddling in the very structure of the system should cease so that the broadcasters can get about the business of serving their constituency: the listeners and viewers of New Zealand.

Despite the fact that it is suggested that communication systems in other contexts could profit from the New Zealand experience, an equally important lesson is that one system cannot provide the definitive paradigm for other situations (22). In particualr, the contributions of single individuals have, in the Reithian tradition, done more to shape a given communication system than the legislative or regulatory framework within which they must operate. A specific problem for New Zealand is that because of the activities of the incumbent, the role of the Chairman has been so expanded that there is no guarantee for the future. Some day there will be the unwelcome problem of replacement, and probable problems of unwanted government manipulation behind closed doors. In particular, there is the ever-present threat that a change of government will upset the whole applecart.

FOOTNOTES

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A SURVEY OF ELECTRONIC MESSAGE SYSTEMS

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Abstract

Electronic Message Systems may soon provide widespread instantaneous written communication at postage stamp prices. Already the market is being deluged by entrics from large and small vendors. But current designs seem ill-fitted to user needs, and standards for interconnection could become a real nightmare.

1. THE EMS REVOLUTION

At Continental Bank, mail is now delivered in seconds, anywhere in the world. More than a thousand employees are now linked by the bank's electronic message systems (EMS). "It gives us a real competitive advantage," says bank Vice President Bob Champion. "I have people in Europe and the Far East, and I can communicate with them as easily as I can with people here in Chicago."

Continental Bank created its message system to enhance the productivity of its managers. Judging from the following comment of another vice-president, Bob Schiewe, the productivity goal is being reached. "I used to get six inches of paer in my in-box every day. Now I get less than half an inch, and the things that come in by computer are easy and fast to handle. I have a lot more time to spend with my managers, a lot more time to do my real job."

To send a message, the manager or professional has two choices: type it directly on a desk-top terminal, or delegate the typing to a secretary. In either case, the message is sent as soon as typing is finished. The next time the receiver checks his or her "in-box," the message will be waiting. In fact, if the receiver's terminal has been left on, he or she will see the message immediately.

The Continental Bank EMS is a large one, with roughly a thousand users. But it is far from the largest. Texas Instruments, for example, has a world-wide EMS; it serves 8,000 terminals and handles more than four million messages each year. And Hewlett-Packard's internal EMS, while not placing any terminals on the desks of individual office workers, has even more impressive traffic statistics: more than twenty five million messages are carried each year.

The message systems at Continental Bank, Texas Instruments and Hewlett-Packard were all in-house developments. But just about every major office products company is now offering or has announced plans for EMS:

All of the major national computer networks in the United States and Canada already offer EMS. Tyment's systems is called OnTyme; Telenet's system is called Telemail; and Datapac's offering is called Envoy 100.

Electronic message systems are also slated for the next generation of computer networks: Satellite Business Systems, Xerox's XTEN, and AT&T's Advanced Communication Systems.

Several time-sharing vendors and software houses offer fairly complete message systems that can be used via time-sharing ordered as in-house software packages, or purchased as in-house turn-key systems. A partial list includes the Computer Corporation of America, Infomedia, Scientific Time Sharing Corporation, Bowne Time Sharing, I.P. Sharp, Cybertec Computer Products, Compuserv, SP Communications and Rolm (who has a PBX-based message system).

All of the major computer equipment vendors seem ready to offer EMS as part of the new "integrated" office systems now being designed and introduced. Tymshare, Datapoint, Wang, Prime, and IBM already offer EMS in their integrated systems. Xerox has offered EMS in all experiments with its prototype integrated system, Alto. DEC originally eyed Computer Corporation of America's COMET system as a DEC offering but has since decided to develop its own EMS program. Wang has even advertised its system on television.

Potentially more important than all of these efforts is the work now underway worldwide to upgrade the international Telex service. The new service, Teletex, now seems likely to be a relatively sophisticated EMS. The development of Teletex is being done under the sponsorship of the CCITT (the International Telephone and Telegraph Consultative Committee), which is the chief international standards agency in telecommunications. Seme countries, notably Germany and Sweden, plan to offer Teletex by 1982 or 1983. If Teletex achieves its full promise, it could make a fairly sophisticated electronic message service available world-wide before the end of the decade.

2. COMPUTER MAIL AND ELECTRONIC MAIL

Many EMS vendors refer to their systems as "electronic mail," rather than EMS. Electronic mail certainly seems to be an apt name, since the messages are delivered electronically. Unfortunately, the term, "electronic mail" is already in use. In fact, electronic mail is already a $2 billion industry -- with little help from EMS. Table 1 gives the author's estimate for the electronic mail industry as it was in 1977.

There are two basic forms of electronic mail: teletypewriter systems and facsimile systems. Teletypewriter systems transmit messages as a string of characters, each character being represented by a seven-to-ten bit code. The most common of these codes in the United States is ASCII, the American National Standard Code for Information Interchange. Facsimile systems in contrast, produce a picture of a page by scanning it, much like a television camera scans a scene or copier scans a printed page. The scanned image is transmitted to a receiver, where it is printed. Facsimile systems are sometimes called telecopier systems.

Teletypewriter systems are desirable because they use much less transmission bandwidth than facsimile. Teletypewriter messages can also be stored in less memory space than facsimile messages. Facsimile, on the other hand, can transmit graphics, letterhead, and signatures. Both approaches can provide high-quality printing at the receiver's terminal. In practice however, printing quality varies enormously in both approaches.

As shown in Table 1, electronic mail is dominated by "private teletypewriters," or PTNs. In PTNs, a message is composed on the sender's teletypewriter. Early teletypewriters prepared messages on punched paper tapes; new terminals have electronic compostition. When the sender is ready, he or she dials the receiving terminal's code. A connection is established via the company's internal switching network, which typically uses common carrier transmission lines but ties these lines together through the company's switches and concentrators. The receiver's terminal prints the incoming messages.

Some PTNs do not require that the sending and receiving teletypewriters be free at the same time; they provide "store and forward" service in which the sender's message is stored in the system until the receiver's terminal is free.

Public teletypewriter networks are available in the United States primarily from the Western Union Telegraph Company, WUTC. Although WUTC does not have a monopoly on teletypewriter services in the United States (ITT, in fact, plans to compete with Western Union), it offers nearly all public services in this country. WUTC's chief public service is Telex, a world-wide teletypewriter system. WUTC also offers quite a number of other services, including telegram services, Mailgram, and Infocom.

The United States Postal Service is attempting to enter the electronic mail market through its ECOM service. In many ways a Super-Mailgram service,

Table 1

ESTIMATED ELECTRONIC MAIL EXPENDITURES IN THE UNITED STATES: 1977
(millions of dollars)

Category		Annual Expenditures
Private teletypewriter networks		$600 - $1200
Western Union Telegraph Company		
Telex/TWX	$240.	
Mailgram	50.	
Telegram	60.	
Other	50.	
TOTAL		$400
Facsimile		$200 - $350
Communicating Word Processors		$ 40 - $100
TOTAL		$1,240 - $2,050

Source: Reference 1

ECOM would let companies such as bulk mailers send teletypewriter messages to local post offices, where they would be printed, then delivered by hand in the next day's mail.

Facsimile, although still fairly small in the overall picture, is growing very rapidly. Before 1970, the hostile interconnection regulations of the telephone system and antequated technology limited facsimile to specialized applications, such as the transmission of newspaper photos. But when interconnection rules were liberalized, an opportunity emerged, and Xerox exploited it aggressively with new technology and heavy promotion. Today, facsimile continues to grow rapidly, often at the expense of private teletypewriter networks.

The picture of facsimile should even brighten in the next two or three years. Both SBS and XEROX are encouraging the use of facsimile on their proposed national networks. Cheap bandwidth, coupled with technology to reduce transmission costs, are being held out to clients as potent ways to reduce their mail costs. In addition, while facsimile interconnection is still far from standardized, several organizations are now providing transmission networks that are claimed to be capable of connecting most facsimile terminals to others. Existing networks -- Speed-Fax, Fax-Pac, and Graphnet -- should grow in power and should be joined by others soon.

Communicating word processors have added an important new dimension to word processing technology: the capability to distribute text after it is created. In early products it was necessary to handle text transfers manually. First, the sender called the receiver; then, they hooked up their systems. Now, however, transmission work is becoming automated. Many units can work unattended. And IBM's 6670 Information Distributor can create a network linking word processors with one another and with printers scattered around the firm.

But there are many problems ahead for communicating word processors. Although many are billed as compatible, most are compatible only in a limited sense: they can exchange streams of text. But when it comes to displaying text on a page or screen -- including margins, tabs, backspacing, underlining, fonts, and so on -- there are no standards. Text that is "successfully" transmitted from one compatible system to another may produce only meaningless jumbles when the receiving system attempts to print it.

It should not be too long before different kinds of electronic mail melt together into hybrid delivery systems. With proper techniques, for instance, text produced from PTN terminals and communicating work processors already can be "printed" on facsimile terminals. Already the OnTyme II service of Tymnet can send messages to facsimile terminals. Optical character recognition, in turn, will eventually be able to convert facsimile images into teletypewriter codes.

3. ELECTRONIC MAIL VS. EMS

Electronic mail differs from EMS in this way:

- Electronic mail is concerned primarily with message transmission. It transmits a message from point A to point B, where it is printed.
- EMS, on the other hand, focuses on the handling of messages before and after transmission: research, drafting, editing, addressing, reading, filing, forwarding, and so on. These costs are very high, totaling somewhere between $7 and $15 when all the materials costs and the labor costs of the sender, receivers, and secretaries are added.

There are other differences between electronic mail and EMS, most notably that EMS terminals are usually placed on the desks of managers, professionals, and secretaries. EMS commands, furthermore, are tailored to general office workers and avoid the odd codes of Telex and many other teletypewriter systems. Electronic mail terminals on the other hand, traditionally have been located in centralized "communication centers" staffed by trained operators. This difference between EMS and electronic mail, of course, does not hold for convenience facsimile units.

4. WHY NOW?

Even the earliest time-sharing systems had rudimentary electronic message systems (2), but these were generally primitive and required incredibly tolerant users. The real spurt in EMS did not begin until the nationwide ARPANET computer network was made operational, in 1972. The ARPANET, an early precursor to Telenet, Tyment, ACS, and XTEN linked research centers around the country. Computer scientists in these centers, who had long maintained informal ties with colleagues in distant locations, soon began to adapt local "mailbox" services to network delivery.

In this hothouse environment, EMS sophistication grew rapidly. A number of the ARPANET systems eventually reached commercial status, and many commercial EMS designs bear unmistakable evidence that ARPANET systems were studied.

But the "ARPANET origin" explanation for the recent surge in EMS is only partly attractive. A number of the current systems were designed in total ignorance of the ARPANET work. Tyment's OnTyme, for instance, was fully operational before its design staff got its first view of ARPANET mail systems.

Another explanation for EMS's current proliferation is based on the fact that EMS is inherently an easy design problem -- at least until some of the tougher design issues are faced. Continental Bank, for instance, had been writing programs since the earliest days of computers, to handle the bank's huge transaction loads in checking and accounting. Gradually, over the years, automation was done at even higher levels. "One day," according to bank vice president Tom Hannagan, "someone asked for a system to exhange messages. We looked at the problem, decided it wouldn't be hard to do, so we did it. We had our pilot up after four man-months of effort when asked why the bank had not done EMS earlier, Mr. Hannagan remarked that it simply had not occurred to anyone.

But this "easy problem" theory too has a weakness. If EMS is so easy, why wasn't it done earlier? To explain the timing of today's many simultaneous introductions, two other explanations seem to carry weight.

First, many firms, like Continental Bank, have recently become concerned with office automation and are increasingly focusing on systems for managers and professionals. Since managers and professionals both spend about 25% of their day reading and writing, the EMS application is a natural "next step" in many companies once word processing has been installed.

Second, the costs of EMS have only just recently become attractive. In 1977, for instance, the Planet message system cost $1.48 per message, not including the cost of the terminal. But new technology has greatly reduced cost. At the Continental Bank, the cost per message in a system of similar power is already under $0.50.

In retrospect, these four factors -- the impact of ARPANET computer mail technology, the basic simplicity of plain EMS, rising user and vendor awareness of office automation and EMS, and falling costs -- are all combining to push electronic message systems out of the laboratory at great speed.

5. USER REACTIONS

Where EMS has been introduced, user reactions have been very favorable. In one recent survey of 210 EMS users in the U.S. Army Material Development and Readiness Command (DARCOM), the author found that reactions to EMS were positive among managers, professionals, and secretaries alike (3). Even among those managers who eschewed terminal work and delegated use of the system to support workers, general reactions were highly favorable. In fact only a handful of people surveyed actually disliked the system; the rest were either favorable or neutral.

Table 2

EXPERIENCED BENEFITS, OF USERS BY JOB CATEGORY AND DIRECT VS. INDIRECT USE [a,b]

Percent Rating Benefits as Strongly or Moderately Felt

	Percentages[c]					Significance Levels[d]		
	Direct Users				Indirect	Direct	Direct	M
	M[e]	P	M&P	S	M	M vs. P	M&P vs. S	D vs. I
Increased long-distance communication	77%	64%	69%	44%	50%	.180	.046	.008
Increased productivity	74%	50%	60%	35%	35%	.245	.002	.004
Decreased time on phone	67%	52%	58%	21%	42%	.316	.001	.056
Increased liking for job	52%	60%	57%	40%	19%	.066	.052	.004
Increased status	52%	48%	49%	35%	24%	.399	.054	.006
Increased effectiveness on travel	48%	49%	48%	10%	24%	.423	.001	.012
Decreased formality in communication	44%	42%	43%	14%	40%	.289	.008	.476
Decreased time reading & writing	46%	38%	41%	22%	26%	.134	.136	.035
Decreased time face-to-face	59%	26%	39%	12%	29%	.016	.001	.007
Increased flexibility of hours	56%	28%	39%	14%	22%	.024	.005	.006
Increased local communication	15%	22%	19%	10%	2%	.474	.051	.006
Decreased travel	11%	8%	9%	6%	14%	.223	.448	.458

Notes:

[a] Direct vs. Indirect: Direct users work at the terminal themselves to send and receive messages; indirect users delegate terminal work to others.

[b] M, P and S: M=managers, P=professionals, S=secretaries

[c] The percentage shown is the percentage of respondents in this job category, say direct managers, that fit the row descriptor; so percentages do not add across or down columns.

[d] Significance tests are based on Kendall's Tau. The figure listed is alpha, that is, the probability that the null hypothesis (that there is no difference across job categories) is true. A single 1-tail inference is assumed. See the section entitled "The Survey" for caveats.

[e] Sample size for all job categories was 210.

Source: Reference 3

The DARCOM survey revealed that users had experienced a complex pattern of hard and soft benefits (see Table 2). Nearly all experienced increase in long distance communication (a strong benefit) in this geographically dispersed organization). Beyond this, benefits varied considerably by the person's job and whether or not they used the terminal themselves. The only benefit widely disavowed was travel reduction. In general, the pattern of benefits found was encouraging. EMS did not revolutionize the lives of managers, but it produced the kinds of steady gains that will probably mark all of our successful office automation technologies.

The DARCOM survey also found that managers maintained strong discretion over how they used EMS. In traditional data processing systems, everyone had to use the system in exactly the same way. Clerical workers, since time immemorial, have been told what to do and how to do it. But managers and professionals have traditionally been told only what to do, not how to do it; and they have tended to develop highly personalized ways of working. In EMS, the first computer-based technology to be adopted widely by managers and professionals, this same pattern of ideosyncratic behavior is emerging.

Some users employ the full sophistication of the system, while others use only a few commands, and yet others delegate all terminal work to secretaries. The presence of light users and delegators bothers many programmer-designers, but a basic marketing reality is that nearly every consumer product has nonusers, light users, and heavy users. Managers and professionals who decide not to use the system heavily are usually neither lazy nor "computer naive." They are simply exercising their traditional responsibility to decide for themselves how to organize their work days.

One of the most promising things about EMS is that it does not appear to be a "hard sell." If care is taken so that the system works well when it is introduced, and if managers are given about one day of introductory training, a relatively high percentage will adopt even today's rather clumsy systems. It appears that EMS's ability to provide rapid message delivery that works even if the receivers cannot come to the telephone serves a real work need for managers and professionals.

6. THE PROBLEM OF STANDARDS

On the ARPANET, a good deal of attention has been given to standardization, so that any EMS program on any machine can exchange messages with other message programs on the network. Even in this hothouse environment governed by a single agency, however, standardization is only partial.

At the simplest level of standardization, different message systems should be able to exchange messages as simple lines of text marked by beginning and ending signatures. This was the first level of standardization attempted on the ARPANET, and it was largely successful. Unfortunately, it was not enough.

Many people on the ARPANET began to get ten or more messages a day, with gusts up to fifty. At these traffic levels, users often demanded ways to scan through their in-boxes and call up old messages by author, date, or title -- just as managers now have to go through older correspondence and through material in his or her in-box. User complaints caused several basic "fields" be standardized: To, From, Subject, and Date, to begin with. This was not too difficult to standardize.

But correspondence is a more complex phenomenon than first appears, and soon many ARPANET systems began to rival the complexities of organizational paperwork. More than two dozen other fields were soon in common use. Despite massive efforts, the ARPANET community was never able to standardize more advanced aspects of EMS.

The ARPANET's inability to create a single standard for message structures is distressing, because unless the user can operate on a message's structure, the biggest potential benefit of computer mail -- its ability to automate some human message handling labor -- will not be felt. Unless standards agencies can create comprehensive standards for message structures, EMS will become a lame medium for communication.

As difficult as simple text messages are to standardize, things are likely to grow even more difficult in the future as "multimedia" messages are created, combining voice, graphics, text, programs, and perhaps even video communication. And even in the limited area of text, two factors will make standardization difficult:

- Many computer messages will be documents prepared on word processing systems. As noted earlier, while most communicating word processing systems can exchange character streams, their approaches to formatting text on a screen or page are deeply incompatible. In addition, many of the newer word processing systems will allow users to specify character fonts, making the screen formatting problem even harder.

- Long documents are extremely difficult to read on a screen. While roughly 70% of all messages will be under one page in length, many will be longer, and the mean message length should be two to five pages. It is difficult to read large documents on a screen. "Structured" documents, however, which allows readers to scan through the document quickly, for instance seeing only headings, have proven readable on a screen. To date, however, we have not even begun to see standards for structured documents.

A second area for standardization, after the basic message structure, is the user interface, that is, how the system appears to users. It is not entirely clear that it will be possible or even desirable to build a single user interface. Such a standard might indeed be desirable, allowing users to move easily between systems. But as long as messages have known and standardized structures, many different user interfaces can be used to handle the message. One approach to standardization would be to allow each user or organization to employ whatever interface they are most comfortable with, at the same time offering a standardized "lingua franca" interface for those who want to use it.

Even if there is standardization, there is likely to be a "product line" of user interfaces, for users with different needs. At a minimum, there should be separate tools for delegators, simple users, and sophisticated users. We may also need special interfaces for different job needs.

A third area for standardization is delivery. At a minimum, the system must be able to get the message from one user to another user's in-box, handling failures nicely when delivery is not possible. It might not be too difficult to design a standardized delivery system to do this.

But delivery is inherently a very complex process as evidenced by our traditional delivery services: the postal and telephone systems. There may be levels of priority, levels of security, levels of reliability -- each allowing the organization to match its needs with the lowest possible cost for delivery.

A fourth problem is how to interconnect address data bases, so that the formal address of an intended recipient can be located. Neither the postal system nor the telephone system has really provided universal "directory assistance;" the post office stops at the company mailroom in large firms, as does the telephone system's numbering in the directory. And neither traditional system provides universal listings. The telephone system, for instance, allows you to reach someone only if you know their approximate geographical location.

Complicating all of these standardization problems will be the fact that there is not likely to be a single EMS distribution network in the United States. At least six national computer transmissions networks will soon be operating, each with a national computer mail service. There also will be numerous smaller networks, run by time sharing bureaus, individual corporations, special interest groups, and even hobbyists. There will be no national control, in all probability, and standards must neither restrict what the big networks can do nor place burdens on small networks. Almost certainly, levels of delivery standards will be needed.

Some standardization efforts are already underway, but the very diversity and lack of coordination among existing efforts is itself disturbing. In all cases, only parts of the problem are being worked on, and many of the standardizing bodies seem unaware of the existence of others. Here is a list of some of the standardization work now under way:

- The Teletex work of the CCITT (International Telephone and Telegraph Consultative Committee) is potentially the most important standardization activity in EMS. Unfortunately, most of the Teletex working members have only a rather superficial view of EMS and seem unlikely even to face the kind of more advanced questions that must be answered if EMS is to achieve its real promise.

- Within the International Federation for Information Processing, Working Group 6.5 is devoted to EMS standards.

- In the U.S. defense research environment, the efforts of the ARPANET community to set standards for message systems provides a rich supply of information on the problems of standardization and on some possible approaches. A draft for a particularly advanced "next generation" standard (4) is now being widely circulated and discussed.

- Separate standards may develop in the area of business forms processing as a result of major working group (ISO TC/154) on Trade Practices within the International Organization for Standards. Since business forms make up about half of all business pages sent each year (see Table 3), the development of separate standards in this area might be highly unfortunate.

- An effort is now underway to develop text formatting standards for communicating word processors. As noted earlier, because the average message will be several pages long, formatting will be very important. This work is being conducted through the American National Standard's Institute's X4A12 committee, Working Group 4.

Clearly, there is no shortage of efforts to bring standardization to EMS. Unfortunately, none of the groups now working on standardization appears to be taking a really creative and thorough view of what EMS may become in the future, and this lack of vision may not produce the best possible standards for the future.

Now that so many incompatible electronic message systems are in place, it is likely that no single standard will ever receive 100% acceptance. The question may be "How do we interwork when more than one standard exists?" One possibility is that just as computer networks now provide code conversion to allow different terminals and computers to interact, future services may be able to translate the protocols of incompatible systems. Perhaps the Teletex standard will even be sufficiently powerful to serve as a least common denominator for such translations. For a further discussion of standards, see Reference 5.

7. WHAT ABOUT THE FCC?

The spectre of Federal regulation has frightened many vendors and quite a few users too. But the regulatory watch word, at least in the United States is now "laissez faire."

In its final decision in the Second Computer Inquiry (Docket No. 20828), the Federal Communica-

Table 3

ESTIMATED WRITTEN COMMUNICATION

FLOWS IN THE UNITED STATES: 1977
(billions of pages)

Category	Correspondence Reports	Business Forms
Intercompany	12	32
Intracompany	22-44	160-800 *
Intraoffice	50-300*	

* Very rough estimate

Source: References 6, 7

tions Commission recently divided all communication services into two categories: basic and enhanced. While the FCC has retained the right to regulate enhanced services, it has decided not to do so, at least not in the foreseeable future.

Even if the FCC eventually did decide to regulate EMS in the future, this would only impact public EMS offerings. Intracompany message systems, which should dominate the industry, are almost certainly outside the FCC's realm of authority, just as private teletypewriter networks are today.

For messages going outside the United States, however, the regulatory picture is very confused. The international record carriers (IRCs) that now handle message communication between the U.S. and the rest of the world are very jealous of their monopoly. Even more jealous of their monopolies are the postal, telephone and telegraph authorities (PTTs) that control domestic communication in almost all countries outside the United States and Canada. The rise of Teletex is likely to strengthen monopolistic trends.

Even companies that only want to send messages to their branch offices in other countries may face major obstacles. When Hewlett-Packard established its internal, world-wide message network, for example, it had to negotiate separate arrangements with many different PTTs. Some allowed HP to use direct dial lines; other required the use of more expensive data channels.

The sum total of the regulatory picture, however, will be very simple for most companies that want to use EMS; more precisely, the picture will be blank.

8. THE FUTURE: AN ATTRACTIVE COST PICTURE

Computer mail's future seems secure. Costs, already low, are likely to fall 15% to 25% each year. By the mid 1980's, the cost per message should be competitive with both postal delivery and interoffice mail.

In fact, if the user is willing to live with message systems that do little more than bare transmission, the cost of EMS is already below bare postage. Texas Instrument's very simple MSG system costs about $0.07 cents per delivered message, not including the cost of terminals (which are usually shared by several users). Hardware for Hewlett-Packard's COMSYS mail system, sold commercially as the HP 2026, costs that company only about $0.50 per message including the cost of terminals.

As EMS costs fall ever closer to parity with traditional hand and postal delivery, we should see a revolution in the way businesses handle mail delivery. As noted earlier, electronic mail is already a $2 billion industry. Yet it has produced these revenues despite costs of $0.50 to $3.00 per message. Its total traffic is insignificant, compared to the roughly one trillion pages of paper U.S. businesses and government agencies exchange each year (see Table 3). EMS's ability to produce delivery at electronic speeds and at postage stamp prices could expand the realm of electronic delivery vastly.

9. FUTURE TRENDS

It is, of course, hazardous to speculate about the future of any rapidly changing high-technology industry. At the same time, an earnest attempt has to be made to anticipate the future, because the state of the art five years from now should be very different from today's systems. Under these conditions, it seems appropriate to close this discussion about EMS with some guesses about what the future may bring.

9.1 REFINEMENT OF SIMPLE SYSTEMS

As noted earlier, building a simple EMS is not vastly complex. Still, it is far from trivial, and most systems whose design begins with a clean sheet of paper end up being somewhat clumsy, flawed, and imperfectly matched to user needs.

Until now, a majority of systems have been designed in isolation and in ignorance of both other design work and user reactions to other systems. It is hoped that designers will soon be forced by the market place to learn from their competitors, in order to develop a differential advantage.

9.2 TACKLING THE NEXT TIER OF PROBLEMS

With few exceptions, today's EMS networks work well only with small user communities. When systems grow beyond a few thousand users, the problems of finding a recipient's formal address becomes very difficult. How many Frank Johnsons are there in a large firm, anyway?

Another problem is missed or incomplete delivery. In telephone calls, it is easy to tell whether you have reached your party or at least someone with the authority to give them a message. In EMS, in contrast, the management required to handle "error conditions" is rarely present in any complete form. One user with little traffic leaves an important message unread for a week. Another has left the company without deactivating her mailbox. Another has gone on a three-week vacation. The managerial work to handle such failures can become fairly large. While machine-based rules can help ("Notify me when the receiver has read the message"), many "solutions" are politically unacceptable.

In the relatively near future, text messages are likely to be carried over the same system as facsimile and perhaps voice messages. "Supercontrollers" already mix text, facsimile and voice. And with microprocessor control, a facsimile device can make a fine printer for text messages when not receiving facsimile. We are only beginning to understand the problems of integrating different forms of communication.

These three problem areas are only a few of the "next tier" difficulties we can identify today. While the exact nature of the next generation of EMS is unclear, this much is obvious: tomorrow's message systems will be highly architectured and complex, not the relatively simple patches of today.

9.3 RESPONSES TO MARKET NEEDS

For nearly all products, different customers have different needs and requirements. As a consequence, we usually divide the market into a number of "market segments," with members whose needs are relatively similar.

In EMS to date, we have generally created fairly complex systems with one to three dozen commands. Even systems that begin simply soon evolve into powerful systems.

But our survey of DARCOM users, as noted earlier, revealed three fairly district user segments:

- Heavy users tend to use much of the EMS's full power. Generally they demand an ever growing number of functions to make their terminal work more effective.

- Light users, in turn, rarely or never use advanced features. They read incoming messages, ignoring filing; and they type replies or new messages, ignoring all but the simplest editing.

- Delegators eschew terminal work, having their secretaries worry about how to use the system.

There has been a strong tendency among system designers in the past to view light users and delegators as being (1) naive, (2) recalcitrant, and (3) disdainful of EMS. In fact, this is far from the case. First, they are not naive. Many users become light users after considerable experience as heavy users. Second, it is difficult to call someone recalcitrant if you cannot prove that they should work heavily at a terminal. Third, the DARCOM survey found that almost all users -- heavy, light, or delegators -- liked the system very much; they just differed as to how to use it.

If there is any naivete around, it is on the part of the system designers who expect everyone to use the system in the same way. In the realm of consumer products, as noted earlier, there are nearly always nonusers (or indirect users), light users, and heavy users.

Obviously, we need a line of EMS products, not just a single product. Heavy users may demand rugged terminals and powerful interfaces. Light users may desire simple terminals if they are to be served economically, and they may need a system with few commands and options. Delegators should be able to dictate outgoing messages and have incoming messages printed for their secretaries to pick up. All should have procedures for working closely with their secretaries, just as they do in paper correspondence. Obviously, all users should be able to exchange messages, and growth paths should be provided for lighter users. See Reference 6 for more details on possible EMS product lines.

By concentrating on heavy users, EMS designers have repeated the errors made in color televison, microwave ovens, cameras. In those instances, designers began with expensive and highly adjustable products. But in short order, they realized that a large number of users wanted lower cost and more automatic (albeit less adjustable) systems. In cameras, for instance, there used to be only two major categories: very cheap cameras (under $50) and expensive complex 35mm SLR costing about $500. Canon revolutionized this market when it introduced its lower-cost, highly automatic 35mm SLR camera, the AE-1.

9.4 STRUCTURED COMMUNICATION SYSTEMS

Few messages exist in isolation. Rather, they are usually generated in response to events or (more commonly) other messages. In turn, they turned to generate new messages. Communication, then, is not entirely free-form; it is usually at least partially structured.

In clerical offices, the structured nature of communications is particularly evident. A salesman phones in an order. A form is filled in sales, then forwarded to and added to in many offices -- plant scheduling, inventory, credit, production operations, shipping, and billing. This and other clerical processes have often been likened to paper work assembly lines.

In administrative offices outside of the military (where communication structuring is intense, as discussed in Reference 8), the structuring is generally looser, but it exists nevertheless. There is structure in the way we put together end-of-the-month financial statements, manage projects, negotiate nurse's schedules, handle customer complaints, and so on.

Very soon, we may see the emergence of message systems that can work with organizational communication structuring In computer conferencing, in work being done at the Wharton School, and in the Military Message Experiment on Oahu, we are beginning to see experiments in this area. Working systems we would hazard to guess, are still three to five years away.

9.5 VOICE MESSAGE SYSTEMS

It has always been assumed that electronic message systems eventually would compete with or be joined to "voice message systems" or VMS.

In VMS, the sender does not type the message. Instead, he or she presses a special "message" key on the telephone, dials the receiver's number, and speaks the message. A button lights on the receiver's phone When the receiver presses his or her "listen" key, the message is played back.

This may seem rather antisocial, but voice messaging addresses the largest failing of the phone system today: that half or more of all telephone calls do not reach the intended receiver.

Until very recently, there seemed to be little prospect that VMS would develop quickly. Voice recordings are very wasteful of memory capacity. To hold even a few dozen voice messages in computer memory normally would require huge storage.

But the storage problem was being solved more rapidly than almost anyone had expected. The Defense Advanced Research Projects Agency had paid for extensive research to reduce the "bandwidth" needed to transmit (and store) voice in digital form. This defense research and private research had reached an advanced state by the beginning of 1980.

Now the first VMS are already in place, and prospects for the future are bright. There is now little doubt that VMS will be generally attractive by the mid 1980's.

Some analysts believe that EMS and VMS will be bitter competitors. "EMS dominance" proponents argue that the written record of EMS and the ease of skimming through old messages will allow EMS to dominate. "VMS dominance" proponents, in turn, feel that the verbal nature of voice messaging make it a sure winner.

Probably, the picture will not be so simple. At Continental Bank, for instance, EMS and telephone answering systems (in a sense, a primitive VMS) are both used, and division of labor appears to be emerging between the written and spoken word. Only time and research can tell how EMS and VMS will relate in the future.

10. CONCLUSION

EMS costs are rapidly falling toward those of postal delivery and interoffice mail. The economic pressures to adopt EMS should soon be very strong in large corporations. Smaller firms too should soon converse over public message services.

EMS will not be a hard sell. As in any other office system, sloppy introduction can destroy enthusiasm very quickly. But EMS has consistently demonstrated the ability to have its terminals placed on the desks of many line managers and to be used by them enthusiastically.

But companies should not lock themselves into any one system too tightly. EMS should evolve at a fierce pace throughout this decade. Several early vendors, like Wiltek, have already failed or have come very close to failure, falling behind the state of the art. The outlook is bright, but there are still a few clouds on the horizon.

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Computer Controlled Radio Broadcasting Network Switching Systems

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Abstract

The paper outlines the program network distribution system used by Radio New Zealand to transmit radio programs throughout the country and describes computer controlled switching systems recently installed to handle the complex routing functions at two major switching centers. These systems are part of a series of computer based equipment projects being evaluated and implemented within Radio New Zealand. The first system described is a simple programmable time clock controller interfaced to the existing manual audio assignment switcher at the network origination center for operator-aided application. The second system which is described in more detail is a fully automated network switching facility at the largest switching node outside of the network origination center. This center now operates mostly unattended.

1. INTRODUCTION

Radio New Zealand (Radio NZ) has recently married two areas of telecommunication technology, i.e. Radio Broadcasting and inter-city audio networking with computer control technology to produce two unique computer controlled network switching facilities for Radio Broadcasting networks. The project is one of a series within Radio NZ in which modern computer applications are being evaluated and introduced to the organisation. Other projects in the series include computer-aided program presentation and on-line computer management services. The latter are being provided from a central computer to stations throughout the country and will initially provjde sales traffic and scheduling facilities and some financial services -- other functions will be added in the future.

The evaluation and introduction of all these systems which have significant future labour implications is being done with a high degree of consultation with staff at all levels.

The paper describes the first computer controlled network switching system installed by Radio NZ in 1979.

2. RADIO NZ ORGANISATION

Radio NZ is a service of the Broadcasting Corporation of New Zealand (BCNZ) which is a public Corporation operating public radio and television in New Zealand. Radio NZ operates 28 commercial stations throughout the country as well as two non-commercial networks; the National Program network and the Concert Program network. Within New Zealand there are also nine private commercial radio stations operated by independent private companies. The two television networks that the country has are both commercial and are operated by Television NZ; also a service of the BCNZ.

Radio NZ's National Program network broadcasts a light entertainment/current affairs program originated mainly in Wellington and relayed simultaneously over a network system to transmitters in 17 centres. The network operates 24 hours a day and contributions, either live or recorded can be inserted at any of the 17 centers for either local or network transmission.

The Concert Program network transmits a serious music and sports program from four centers for approximately 12 hours per day and from a fifth center for 5 hours per day. This network is also mostly originated from, and controlled in Wellington

The 28 commercial stations all operate independently for most of the day, however, the majority, i.e. 25 stations, broadcast network news and a few other short network programs such as sports and rural programs throughout the day. Additionally it is current policy for 24 of the commercial stations to link each evening from 7 p.m. to midnight when they relay a common commercial program originated usually in Wellington. Several of the smaller commercial community stations link with the National Program or with a neighbouring main center commercial station for differing periods during the day.

To enable all of this to take place Radio NZ leases on a full-time basis 10 KHZ program circuits from the national telephone and telegraph carrier, the New Zealand Post Office. Individual circuits are leased for the National, Concert and Commercial networks. An additional network of circuits will be used in the near future for data communications necessary for the on-line computer management system. A map of the program networks in the North Island of New Zealand is shown in Figure 4 and gives some idea of the complexity.

The map shows circuits radiating out from the network center in Wellington and passing through stations en route to the extremities of the networks. This produces major nodes at regional locations such as Hamilton, Auckland and Palmerston North in the North Island and Christchurch and Dunedin in the South Island where circuits are distributed to a number of regional stations. Smaller nodes exist at other "through-route" locations.

When not in use for scheduled program networking extensive use is made of the circuits for random interchange of program material between stations and also for telephone traffic between Radio NZ offices throughout the country.

All of this adds up to a highly complex switching operation which until recently has been carried out entirely manually on radio stations at each node of the system. This past operation suffered from varying levels of operator error and provided periods of very inefficient staff utilization (for example switching schedules in the evenings are very light and often only require one or two switching operations per hour).

Recently Radio NZ has installed two processor controlled network switching facilities.

i. A simple programmable time clock to control some network switching at the network center in Wellington. (This central focal point in the national system remains manned).

ii. A comprehensive computer controlled switching system at Hamilton, the biggest switching node outside of Wellington. This center is now operated unattended for the major part of the day.

It is proposed that similar facilities to those in Hamilton will be installed at other nodes in the future after satisfactory assessment of these initial systems.

3. NATIONAL SWITCHING INSTRUCTIONS

Operations throughout the country are co-ordinated by the preparation of a daily national switching schedule. This is produced in Wellington by a technical operations center from information produced by program and technical departments as well as regional stations.

The switching schedule is transmitted to all Radio NZ stations via an internal telex network and at each center it is translated to local switching instructions for the local operator.

Preparation of the national schedule is currently done manually although it is expected that this process will be computerized in the near future as one of the computer management projects. At that time, the possibility of interfacing the central management computer with local automated network switching equipment will be considered in order to improve the efficiency of programming automated switching systems. This interface is likely to be via an intermediate medium such as data cassette, floppy disc, or even paper tape.

4. AUTOMATION AID FOR NETWORK ORIGINATION CENTER

A simple programmable time clock controller has been interfaced with the existing manual audio assignment switcher at the network origination center in Wellington. This allows a large number of the regular network switching assignments to be completed automatically. The controller also automatically releases program circuits for telephone use when not required for network programs and automatically returns them to the program assignment switcher prior to their use for program feeds.

The equipment which was designed and constructed within BCNZ as a programmable controller for transmission stations is regarded as being only a temporary facility until more extensive automated equipment is provided at this location in the future. It is probable that this central nerve center of the organisation's operation will continue to be manned for most of the time with any automated facilities acting as an operational aid.

In its short period of use so far the equipment has reduced switching errors and is easily able to cope with multiple event switching operations. The need to execute a number of switching operations at exactly the same time was becoming increasingly frequent and such operations were often difficult to perform manually with a single operator.

The following list of features indicates some of the facilities the controller provides:

a. 900 events of memory;

b. Control for 32 functions;

c. Quartz-crystal time control - automatic daily time check and correction has been included. This is achieved by comparing the clock's timekeeping against the national standard;

d. Program events entered via thumbwheel switches;

e. Three-day battery back-up supply;

f. Basic hardware consists of an RCA Cosmac microprocessor with 2758 EPROM memory.

5. FULLY AUTOMATED NETWORK SWITCHING AT HAMILTON

The fully automated switching equipment recently installed in Hamilton is very much more complex and comprehensive than that just described. The facilities were specifically designed to provide automatic network switching at any of the major switching center nodes on the Radio NZ system.

The equipment provides not only the interconnection of specified circuits at programmed times, but also provides a number of external control features. For example, it includes control for tape and cartridge machines to allow for automatic insertion of locally recorded programs into the networks. To do this the equipment has to execute switching events on "time " based instructions as well as on the detection of audio cue tones (known as "end of message" cues) which are recorded on tape or cartridge material to indicate the end of the information segment on the tape.

6. SYSTEM DESCRIPTION

The system design is shown in Figure 3. The central core is a 40 input, 30 output Dynair System 21 audio cross-point switcher. This is controlled by a central processing unit (CPU) which is a Computer Automation Alpha L.S.I. 2-10, 16 bit minicomputer. Memory storage is split between the 32K words of computer core and a dual drive Computer Automation floppy disc unit. A voltage controlled audio fading amplifier is provided at the output of each switcher bus. These amplifiers are controlled by the CPU so that fade or cut transitions between sources are possible. Event instructions are entered into the computer via a visual display unit (VDU). The system is designed to accept three input terminals but currently only one (a Lear Seigler ADM 42) is being used. All operations performed by the equipment and fault conditions are logged on an LA36 Dec printer. The accurate timekeeping for the system is provided by a General Electronic Development master clock which provides a time reference to the CPU as well as buffered outputs to drive clock units around the station.

Two PABX operator units provide external control for the telephone operator to interconnect program circuits for telephone use when the circuits are available for this purpose.

The CPU also controls 100 general purpose output lines for use in switching on and off a range of ancillary equipment throughout the station. Control is provided by the CPU for the record, play and stop functions on up to four reel-to-reel tape machines as well as addressing and control of up to two Cetec Schaffer, 48 tray Audiofile cartridge machines.

7. SYSTEM OPERATION

The full capability of the system is very extensive and only a basic description of its operation can be given in this paper.

The inter-city network circuits appear as inputs and outputs of the central audio switcher along with the tape and cartridge machines and many other radio station sources and destinations. Any switcher input can be connected to a single or a number of outputs depending on the event instructions in the CPU which controls the switcher.

Switching instructions are loaded via the VDU into "tables" within the CPU. There is a "table" for each day of the week. (Extra "tables" are available for special days such as Christmas, Easter, etc.) Each switching event is defined by the following information:

a. Event number

b. Event time to nearest second

- or -

End of message source if a "cued event"

c. Source

d. Destination

e. Duration - to nearest minute . This defines the time that the particular program circuit will be "barred" for telephone use.

- or -

Control code if the event is not a circuit switching event.

f. Transition - blank = cut, I = fade in, O = fade out, V = vee fade

g. Comments.

Any event held on any "table" may be displayed on the VDU so that it can be altered or deleted. New events may be inserted anywhere in any "table". The system is capable of storing approximately 10,000 events (dependent on the length of comment field).

Three typical event instructions are as follows:

Event.	Time	Source	Dest.	Dur.	Trans.	Comment.
1	1000 00	21AK	45WN	0015	I	News
2	1020 00	44WN	REC1	0010	I	Record "Today in Sport."
3	1030 00	MUTE	REC1	0000	0	Stop Tape

Event 1 programs the interconnection of circuit 21 to Auckland with circuit 45 from Wellington for a duration of 15 minutes for a news link at 10 a.m.

Event 2 instructs the equipment to switch circuit 44 from Wellington to tape recorder 1 and to start the machine recording at 10.20 a.m. to record the program "Today in Sport."

Event 3 is entered to stop the tape recorder at the conclusion of the above recording at 10.30 a.m.

As well as these simple operations illustrated the equipment is able to execute nearly all the complex of operations necessary at the Hamilton switching centre.

Many software features are included in the system such as "minimum recognition" of mnemonic codes, extensive data checking of input information, error message readouts, and many different system status and memory content displays.

Splitting of the memory capability between core and floppy disc was an economic compromise and in practice is handled by having the software executive, several hours of events, and the immediate log held in core. As the core empties of events, the computer replenishes it from disc and writes the log to disc. In order to reduce the wear on the disc transport mechanism the computer switches the unit off during periods of low activity when there are no transfers of data required between disc and core.

8. EQUIPMENT CONTRACT

The system was supplied by a New Zealand industrial control and computer software company, Progeni, as the result of international tenders. As indicated in the system description most of the hardware is made up of standard computer units which were imported and configured by the contractor who designed and wrote the system software. The final product represents the very successful result of close co-operation between Radio NZ and the contractors.

9. CONCLUSION

A range of new telecommunication/computer technology applications are being evaluated by Radio NZ and such equipment is being introduced in areas where it can increase the quality and efficiency of the radio broadcasting product. Planning and evaluation of the new systems is being done by a multidisciplinary team of staff at all levels.

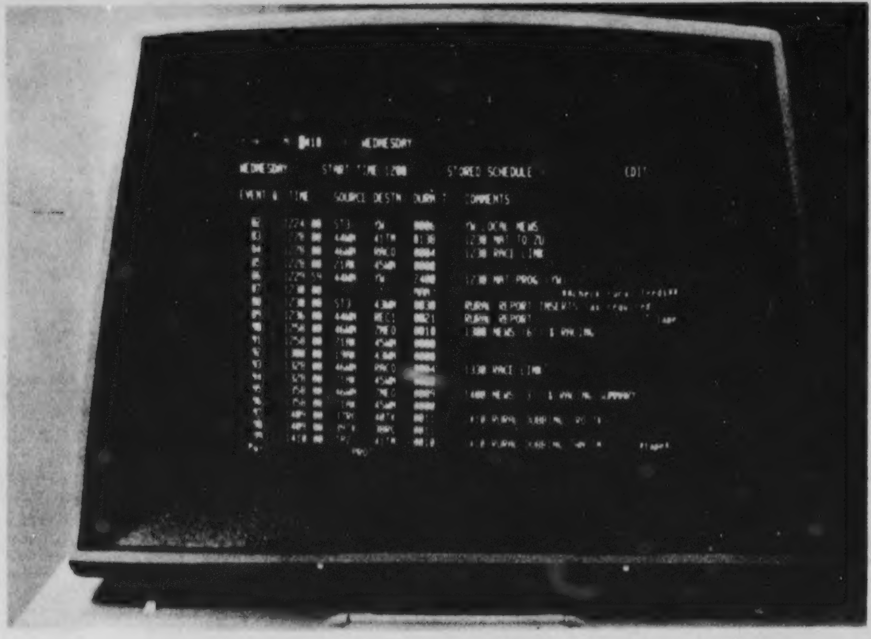
WEDNESDAY
WEDNESDAY START TIME 1200 STORED SCHEDULE EDIT
EVENT # TIME SOURCE DESTN DURN COMMENTS

FIGURE 1
Current Schedule
Real Time Display
(Dynamic)

FIGURE 2
General View of
Master Control Room

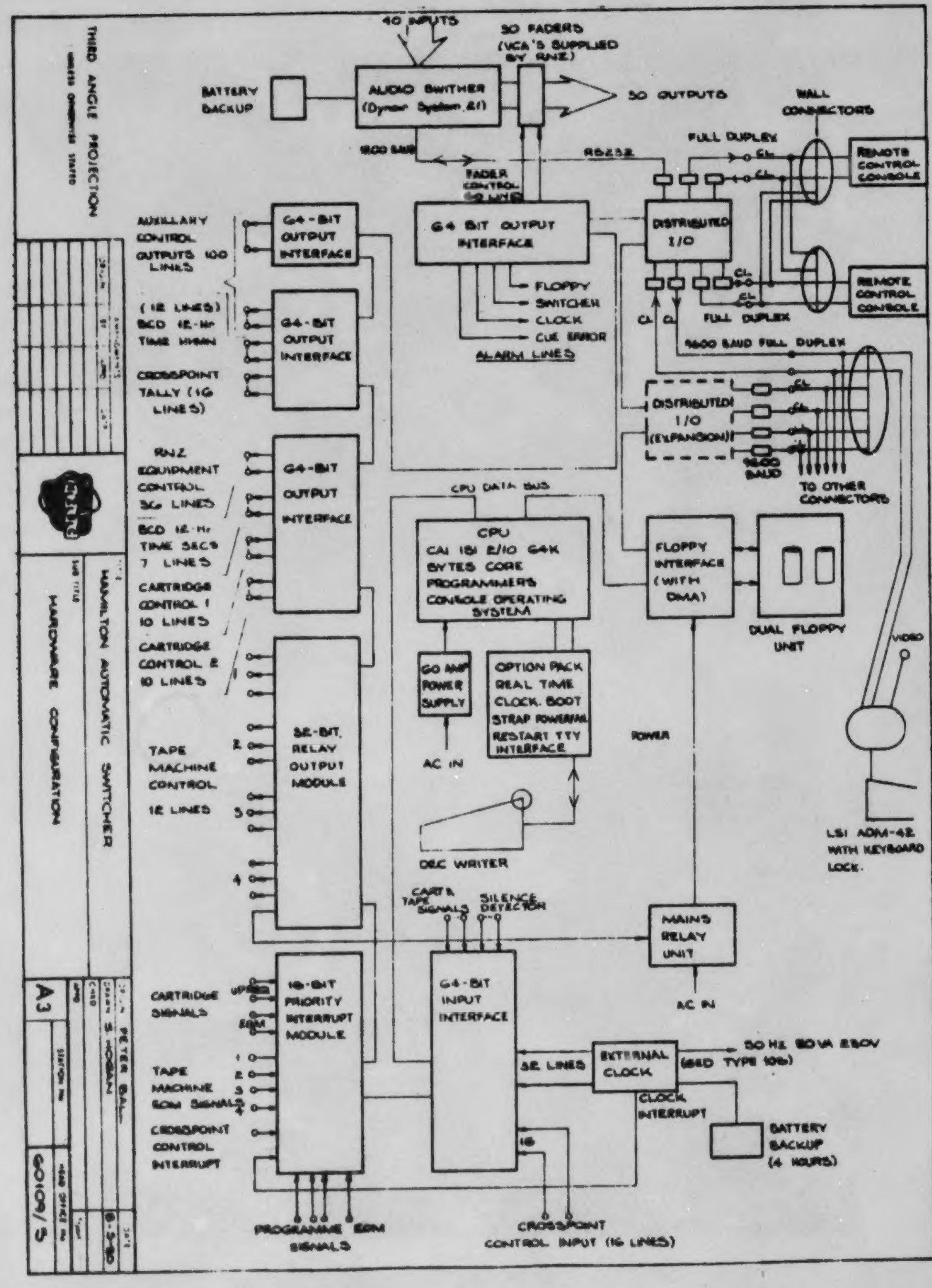
THIRD ANGLE PROJECTION
UNLESS OTHERWISE STATED
HAMILTON AUTOMATIC SWITCHER
HARDWARE CONFIGURATION
PETER BALL
S. HOGAN
6-3-80
A3
G0109/5
40 INPUTS
30 FADERS
(VCA'S SUPPLIED BY RNZ)
BATTERY BACKUP
AUDIO SWITHER (Dynair System 21)
30 OUTPUTS
WALL CONNECTORS
1200 BAUD
FADER CONTROL 60 LINES
RS232
FULL DUPLEX
REMOTE CONTROL CONSOLE
64 BIT OUTPUT INTERFACE
DISTRIBUTED I/O
FLOPPY
SWITCHER
CLOCK
CUE ERROR
ALARM LINES
FULL DUPLEX
REMOTE CONTROL CONSOLE
9600 BAUD FULL DUPLEX
AUXILLARY CONTROL OUTPUTS 100 LINES
64-BIT OUTPUT INTERFACE
(12 LINES) BCD 12-Hr TIME HHMM
64-BIT OUTPUT INTERFACE
CROSSPOINT TALLY (16 LINES)
DISTRIBUTED I/O (EXPANSION)
9600 BAUD
TO OTHER CONNECTORS
RNZ EQUIPMENT CONTROL 36 LINES
64-BIT OUTPUT INTERFACE
CPU DATA BUS
BCD 12-Hr TIME SECS 7 LINES
CPU CAI LSI 2/10 64K BYTES CORE PROGRAMMERS CONSOLE OPERATING SYSTEM
FLOPPY INTERFACE (WITH DMA)
DUAL FLOPPY UNIT
CARTRIDGE CONTROL 1 10 LINES
CARTRIDGE CONTROL 2 10 LINES
60 AMP POWER SUPPLY
OPTION PACK REAL TIME CLOCK, BOOT STRAP POWERFAIL RESTART TTY INTERFACE
VIDEO
TAPE MACHINE CONTROL 12 LINES
32-BIT RELAY OUTPUT MODULE
POWER
AC IN
DEC WRITER
LSI ADM-42 WITH KEYBOARD LOCK.
CART & TAPE SIGNALS
SILENCE DETECTOR
MAINS RELAY UNIT
AC IN
CARTRIDGE SIGNALS
16-BIT PRIORITY INTERRUPT MODULE
64-BIT INPUT INTERFACE
TAPE MACHINE EOM SIGNALS
32 LINES
EXTERNAL CLOCK
50 Hz 50VA 230V
(ESD TYPE 106)
CLOCK INTERRUPT
CROSSPOINT CONTROL INTERRUPT
BATTERY BACKUP (4 HOURS)
PROGRAMME EOM SIGNALS
CROSSPOINT CONTROL INPUT (16 LINES)

FIGURE 3

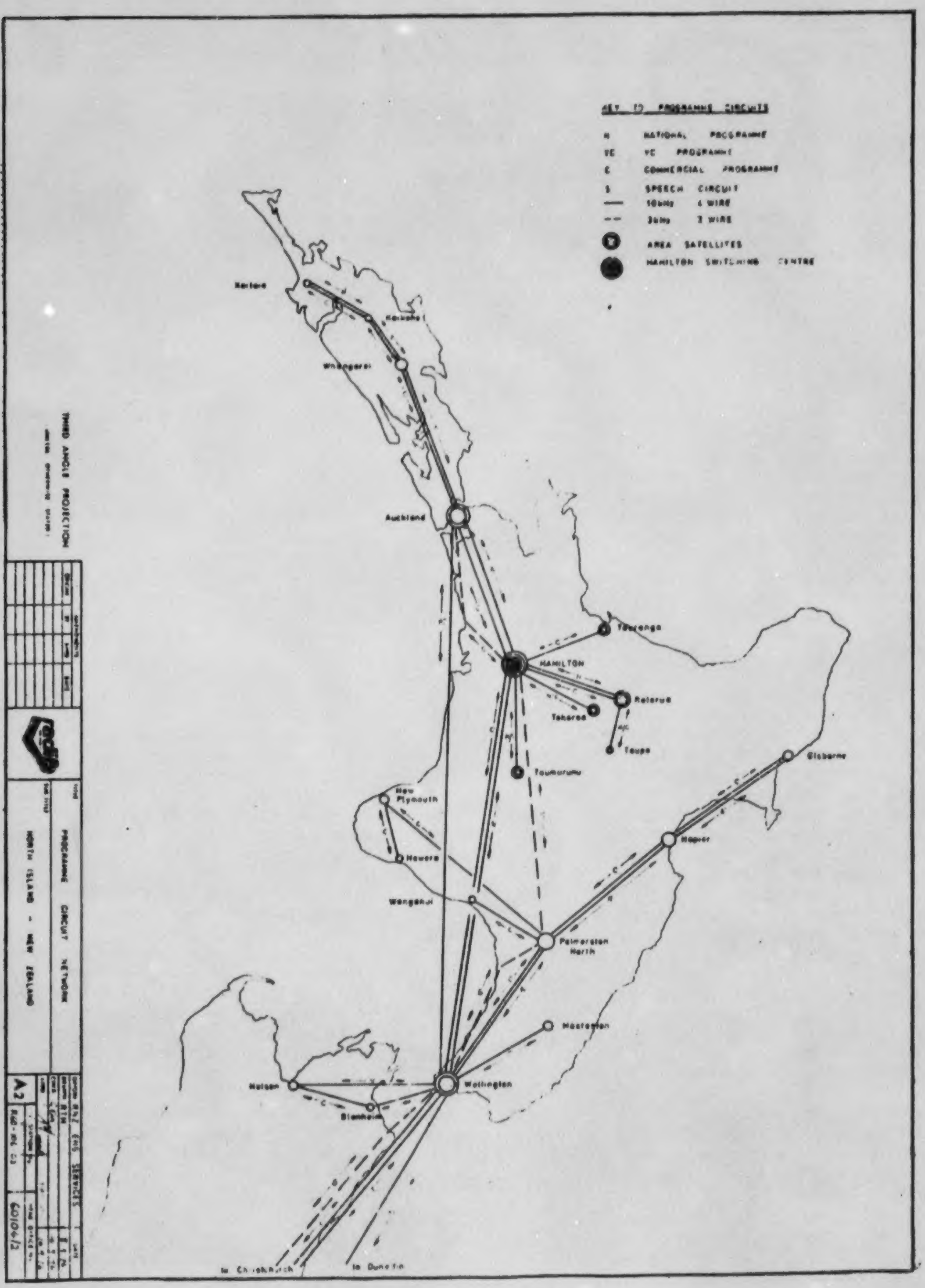
KEY TO PROGRAMME CIRCUITS
N NATIONAL PROGRAMME
YC YC PROGRAMME
C COMMERCIAL PROGRAMME
S SPEECH CIRCUIT
— 10kHz 4 WIRE
-- 3kHz 2 WIRE
AREA SATELLITES
HAMILTON SWITCHING CENTRE
Kaitaia
Kaikohe
Whangarei
Auckland
Tauranga
HAMILTON
Rotorua
Tokoroa
Taupo
Taumarunui
Gisborne
New Plymouth
Hawera
Napier
Wanganui
Palmerston North
Masterton
Wellington
Nelson
Blenheim
to Christchurch
to Dunedin
THIRD ANGLE PROJECTION
PROGRAMME CIRCUIT NETWORK
NORTH ISLAND - NEW ZEALAND
BNZ ENG SERVICES
A2
60104/2

FIGURE 4

A3-17

NO COOKS IN THE KITCHEN
RESTRICTIONS ON THE GROWTH OF DATA NETWORKS

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Abstract

Major U.S.-based multinational corporations and financial institutions are the targets of the large number of vendors offering communications systems or services. Virtually all industry watchers and forecasters are citing dramatic growth in Value Added Network services, private data networks, local networks and data use of public common carrier systems. This paper presents the results of interactions with over thirty major firms and the dramatic impact to be expected on the pace of installation of effective network systems as a result of the limited information communications expertise.

I. INTRODUCTION

When one works within a high-technology services organization, the associations are with individuals who are acutely aware of the state of technology across a rather broad front. In the remote computing services industry, data/network communications is an area of particular interest and for which there exists significant expertise.

As a result of interacting with such individuals, a false sense of the real world can be built. That is, everyone knows about data and network communications techniques, alternatives, and implementation/operational considerations. Wrong!

During the past nine months various client assignments have resulted in specific reviews of the data communications knowledge, capabilities and plans of major firms. It became evident very early that the assumed level of expertise within major manufacturing, transportation, energy, distribution, financial and services firms, among others, was at a very different level than needed to apply the available data communications technology and services to the set of needs.

In several instances, openings for data communications personnel had not been filled for periods of up to one year. Qualified candidates just were not available. However, many of the firms were conducting business as usual without a realization of the deficiencies of the responsible data communications organization(s).

The challenge then is for business and industry to recognize the roll of information movement systems and the requirement for technically-aware expertise that can conceptualize the required solutions and manage their planning, procurement, installation, operation and evolution.

II. CHALLENGES OF THE 80'S

As we enter the decade of the 80's, technology places before us the challenge of multiple opportunities for "advancement" in information processing and handling fields. Each of these opportunities, individually, can consume the technical and managerial energies of a firm.

Included in this set are mini computers, data and network communications and office automation. This paper will focus on the challenges and expectations of providing adequate information movement capabilities to satisfy the needs of business and industry.

It is important to note that with the dramatic proliferation of mini computers, intelligent terminals, office automation products and ever-increasing participation in international markets by U.S. firms, the communications foundation necessary to support these "new" requirements generally isn't in place. We find that point-to-point communications links have been a relatively satisfactory solution, but the pace of introduction of new products, technologies, and business needs have resulted in communications needing to make up some 5 or more years of lost time.

If the proper foundation hasn't been established for meeting the needs of information movement requirements of the early 80's, what has happened? All too often the initial data communications need was satisfied by a request to the telephone company to install a circuit and a couple of modems. The ordering was initiated by a systems or applications person through the voice services department of the company. Over time, data communications grew and a technician was added to the staff reporting to an operations manager or supervisor. Today, that staff may be one or several, but is still very black box and EIA oriented.

As a result of the growth of this data communications activity over the past several years, the firm has a very extensive network. Wrong! It has a large number of data communications links and is also using excessive amounts of the company's voice network for dial-up data traffic.

The challenge of the 80's, therefore, is to establish an organization with the required level of technical and conceptual expertise to develop information movement systems to handle existing requirements of the business. Then the efforts must be focused on being prepared to meet the needs posed by office automation, the proliferation of other intelligent terminals and minis throughout the firm, and the exchange, via internetwork communications, of information with other firms and businesses throughout the world.

III. EXECUTIVE INFLUENCES AND PRIORITIES

Increasingly, two (2) additional influences are beginning or are continuing to have considerable impact on the development and evolution of information movement systems within the firm. The first is the role of senior management. It has been and continues to be a rare case when this level of management has an awareness of or an appreciation for the importance of information communication systems to a firm's efficiency in conducting business and the maintenance of a competitive position within its industry.

Over the years, senior management has been faulted for not elevating the position responsible for information systems or data processing. Now the same concern is being voiced about information systems and data processing managers for not identifying the importance of and elevating the function responsible for data and network communications. Today, the majority of organizations still have technicians responsible for communications and have the function of reporting at a level inconsistent with the scope of service that is being requested and required.

Where there has been an organizational recognition of the role of information communications systems, all too often the combining of voice and data services results in management that has experience exclusively in voice communication services. As a result, one frequently sees a premature effort at integrating voice and data services. Again, this occurs before the required foundation of expertise and services are in place.

The second influence referred to above is that of priorities. The priorities relative to creation of a comprehensive, adequately flexible and general information communications system which satisfies the current needs of the business or addressing the speculated needs of office automation or electronic message systems.

Communications capabilities and expertise are five or more years behind the available technology and user's desires. The most critical assessment that must be made by management is the ability of the total organization to assimilate the technology and systems which are proposed to be installed over various time periods.

Key will be the staff responsible for the various elements of the information communications system. Not only will there be a major problem of assimilation by the total organization, the information communications group will become so diluted with conflicting priorities as a result of multiple "advanced" projects being underway that the communications services required to facilitate successful use of these new systems will break down and fail to adequately provide the required services.

IV. DATA COMMUNICATIONS GROWTH

At this point, it is appropriate to assess the magnitude of the data communications activity over the next several years. To do this the estimates of the realizable markets for the installation of turnkey private networks and value added data communications network services have been used.

Since some portion of the private networks market will be satisfied by specialized enhanced communications carriers, the information presented isn't intended to represent a net market forecast.

Future forecasts of private network installations are:

SOURCE	YEAR	ANNUAL REVENUES FORECAST
A. VAN Vendor	1985	$600 Million
B. VAN Vendor	1995	$725 Million
C. RCS Vendor	1981-1985	$ 1 Billion
D. Common Carrier	1981-1985	$ 1 Billion

Along with the expected growth of private networks will be the entry of several new service organizations as well as the evolution of present service firms in the offering of enhanced or value added communications services. The following are industry forecasts of the growth of these services:

SOURCE	YEAR	ANNUAL REVENUES FORECAST
A. Market Research	1982	$370 Million
B. Market Research	1984	$1,300 Million
C. Market Research	1984	$1,000 Million

Revenues expected for 1980 are on the order of $50 million for private networks and $100 million for enhanced communications services in total. One can readily see that a many-fold growth in the use of information communication services is expected over the next several years.

V. AVAILABLE NETWORK COMMUNICATIONS ALTERNATIVES

There are three (3) principal approaches currently available to firms in addressing their information communications needs: (1) develop solutions internally, (2) acquire turnkey private network capability, and (3) use of public value added services.

Within the first two alternatives are numerous vendors providing the components to build one's own capability as well as an adequate set of suppliers offering the total solution via turnkey networks. Value added services, practically speaking, are currently limited to two vendors. However, in the next two years, one can expect at least three to five additional value added network suppliers.

Add to the above the considerations for extending one's network to Europe and the Far East. Also, it will be found that virtually all multinational and large domestic firms will require more than one information communication system to satisfy all of their essential requirements.

If one is to comprehensively assess the available alternatives within each of the approaches there would be at least ten to twelve. Then compound the assessment process with overall planning and management considerations when international communications are involved. It is not a task for a technician, nor is it a task for a one-person or part time staff.

VI. MEASUREMENT OF AVAILABLE EXPERTISE

The material reviewed above has cited the considerable dependency that business and industry has on those responsible for information communications systems. To achieve the expectations of management and to implement communications services and products dependent upon such capabilities, it is essential that we understand the current status of the expertise within firms utilizing communications systems and within those firms offering solutions in the form of services or products.

It is important to note that there are very large numbers of technicians and engineers who are very competent and familiar with elements of the information communication system. What is of interest and importance to management is the availability of individuals who can guide all facets of an information communications capability for a firm.

Let's now review several specific examples of information communications activities which have recently occurred or are currently in process in major U.S.-based companies.

VII. EXAMPLES OF EXPERTISE TODAY

The intent is to reflect on a condition that is prevalant across virtually all business sectors and all sizes of firms. What may sound extreme in the following examples is indeed occuring today. Comments are not made to belittle or make light of the circumstances cited. It is important, however, to call attention to a matter of fact situation which must be addressed by management to assure successful business operations.

The examples reviewed below are taken from the financial community,(very large banks, securities industry, and computer services industry specializing in servicing medium-sized banks), manufacturing, and energy industries. In this age of rapid change, the reference to "history", relative to these examples, addresses incidents that have occured during the past several months or are currently taking place.

A. A major financial institution has some nine (9) application specific data networks. As new services are being planned for its marketplace it has found that the majority of the required data is already being captured in other established systems. However, the new service or application will be on processor X and the needed data is part of applications on processors A and B. Further, the "networks" supporting the applications on A and B are exclusively for these applications.

To facilitate the rapid and user-transparent movement of information throughout a network which has in excess of 100 sites, the firm initiated a project to create a single integrated, highly flexible network. That was in early 1979. They expected to create the required data communications network by late 1980.

Today, after almost two years, a plan has not yet been drafted for the proposed project. Instead, since the project was part of operations, considerable concern was raised about the vunerability of a current set of application networks to major outages and deficiencies in the areas of daily network management and backup/-redundancy. The focus, therefore, has shifted to addressing the daily operational environment of the current applications specific data communications systems. The result of this change will be the establishment of a long overdue network control center.

However, the number of physical sites to be supported by this institution are forecasted to increase by at least 300% in the next eight (8) years. In addition there will be the natural growth of information movement needs and the addition of new services to be offered through all locations of the firm. The current efforts with the exisiting network are essential. However, there still does not exist a planning project to initiate the activities towards the development of the replacement network with its added functions and capability.

B. Another financial services firm has operations throughout the United States. The company is made up of several wholly owned subsidiaries, several acquired in the last few years.

Each of the businesses are oriented toward timely customer service with virtually all customer interaction via personal telephone contact or data transmissions.

During the past several months considerable attention has been given to the cost and function of the communications systems in use. The expectation was that the current fragmentation could be analyzed resulting in lower costs with at worst the same level of service, but with hope held out for an improved service environment.

Progress to date has been the minor elimination of some under-utilized circuits in one business. More importantly, in the absence of an internal person capable of handling the responsibility of performing or guiding an overall analysis resulting in sound recommendations, outside resources were sought. This resulted in consultants being retained to analyze the current usage patterns, perform a requirements analysis and recommend corrective action.

Early in the efforts of two separate consulting firms, hardware solutions were recommended prior to completion of the analysis. In each case there was a financial relationship between the consulting firm and the recommended hardware vendor. These relationships were terminated.

Still, even though the business is virtually 100% communications-based and dependent, only one subsidiary has an individual with communications as a specific responsibility. As a result, and very exceptionally so, a member of senior management has been addressing the information communications needs of the total firm. However, in this case there is an excellent perspective on the needs of the business on one hand, matched with very little technical appreciation on the other. Finally, and most importantly, any attention given to the area of communications by this individual is necessarily very intermittent.

C. The involvement of U.S.-based firms in international commerce is growing at a very significant rate. Successful performance by these firms in the international market place is increasingly a function of their ability to handle the movement of business transactions and information quickly, efficiently, and economically.

A financial firm with operations throughout the U.S., Europe, Asia and South America has found that its competitive position in international markets is being eroded, in major part, as a result of inadequate information movement capabilities.

Presently, Telex and courier servies are the principal means of communications with foreign sites. The most recent change in international communications within this firm was the increase from $^1/_2$ speed to $^3/_4$ speed for the Telex service.

Required and expected by management is the timely availability of information as to specific country economic data, complete office accounting data, customer status on a global basis, and the ability to request and receive special information through a highly reliable and timely message system. In addition, there is a requirement for access to and integration of at least four (4) additional network services which are specific to, and required by firms in the financial services industry.

The realization of the above expectations and satisfaction of the communications requirement has been and is dependent upon resources which have been exposed exclusively to Telex services.

D. Limited communications expertise and resources frequently result in major or even rather routine communications activities being deferred in favor of "higher priorities". Higher priorities result due to data processing management reverting to the familiar, installing new hardware and/or software, rather than pursue, in parallel, the greater unknown of establishing a more functionally powerful and flexible data communications network.

An energy firm has acquired additional subsidiaries as well as established major new operational sites in the last two years. Management has the objective of providing the same level of information-handling services for the remote locations as are available to headquarters located organizations. To accomplish this objective the current point-to-point data communications links will be replaced by a significantly enhanced communications network.

Efforts towards establishing an overall program schedule and identification of the appropriate and necessary resources were to begin earlier this year. Some nine (9) months later the program has yet to be initiated. Since the communications staff capability consists of a data communications technician who maintains the modems and circuits, the data processing director was to manage the communications program. However, a major mainframe installation and DBMS conversion program has taken a higher priority and resulted in the deferral of the network program.

E. A final example. One of the largest manufacturers in the U.S. has many thousands of miles of data communications links between major operations and the headquarters computing facility. Services range from 300 bps asynchronous to 9600 bps synchronous. A few locations are served with multiplexers, the remainder consist of a single leased line per terminal.

In 1978, the data processing services organization set as an objective the initiation of a planning effort for a replacement network with increased function and capability. One of the major divisions of the firm has recently added both mainframe hardware and supporting communications due to its inability to utilize corporate computing systems via the limited functions and services of the corporate "network". Corporate data processing, today, still intends to plan the new network.

Time and space do not permit the review of many similar examples of firms which are having considerable difficulty utilizing electronic based information systems. The reduced cost of the mini computer, competition motivated services, among many other reasons, are creating a level of complexity in solutioning the information delivery system problem such that it is beyond the experience of the vast majority of those responsible for communications systems.

VIII. TODAY'S REALITIES

What are the reasons for the lack of progress in satisfying the data communications needs of business and industry? There are very few individuals that have had the opportunity, time and, therefore, experience of conceptualizing and creating or acquiring extensive and functionally sophisticated information communication systems. In short, the pace of utilization of the computer has outstripped the development of the required expertise to manage the development, operations and evolution of the required information communications systems.

The typical individual responsible for data communications was previously involved with voice services, part of the systems software group working with the communications modules, or a communications hardware technician.

All too frequently requirements for service in support of a new application or remote site are taken to AT&T for assistance. The result is an AT&T solution. Nothing more, nothing less. An example which occurred within the past two months, saw a novice trying to establish a link between the U.K. and the U.S. The AT&T solution was about $4000 per month. This approach was viewed by the requesting company as being very acceptable in light of the requirement being for international data communications. Upon being exposed to a broader set of alternatives the firm selected a VAN service which would be more reliable, straightforward to use and is expected to cost about $600 per month.

Personnel responsible for telecommunications do not have an awareness of the available alternatives. Therefore, only one approach is being pursued and it is frequently the most costly, and offers minimum flexibility in addressing future requirements.

Even when more than one solution is evaluated, there is very often a bias, which ranges from modest to very strong, to "do it in-house". That is, to take on the full responsibility of planning the information communications network, selecting the components, writing some of the software, integrating the components and generating the ultimate custom solution.

When this approach is selected, it is done so for reasons of control and meeting the "special" needs of the firm. However, an extremely small fraction of major companies have the expertise and time to pursue this most risky solution of all. With the stated scarcity of personnel with requisite skills this approach most often compounds the problem rather than meet any of the reasons given by the firm initially.

The technician or loyal employee put in charge of data communications does not have the background to properly conceptualize the overall needs of the firm and then orchestrate the elements which are essential to a viable communications capability. As a result communications are installed not planned, interconnectivity is addressed separately for each application, reliability and availability are not understood, measured or are considered to be too costly to achieve the levels desired. In addition the potential for growth will be limited, function insufficient even in the near term and flexibility will be severely restricted under this direction.

Individual managers attempting to satisfy the needs of their business unit will, in light of the insufficient function and flexibility of corporate communications, begin to solution problems specific to their unit. This results in the creation of many stand-alone "networks" to service individual divisions, considerable redundancy in capability without the benefits of improved reliability and a very significant cost in staffing and creating data communications expertise within each division.

Further, the inclusion of communications responsibility within the division results in the dilution of management time and attention to the needs of the business unit, increases staff, which is highly susceptible to turnover, and adds costs and operations responsibilities inappropriate to their prime million.

Since there exists on the order of only a few hundred individuals with the required capabilities cited above, traditional solutions are the order of the day. That is, more application specific data communications are installed, situations occur where several FAX units all communicating with the same European city continue to incur costs in excess of a leased line, and over thirty remote sites are planned to initiate communications with the same host computer on the same day within a narrow time window transmitting several million bits per site per day, among many more examples.

As firms increase the level of use of data processing systems and associated remote hardware it will be found that a single communications solution is less and less likely to meet the full set of needs. Required will be an internal private network, use of VAN services, industry specialized networks and international public data network services. The solution alternatives cover such vendors as remote computing service firms, GTE Telenet, Tymnet, ITT, future services of AT&T, XTEN, SBS and specialized service firms. Each has or will have particular capabilities and limitations.

The absence of capable information communications expertise will result in turning to a vendor for the required solution and assistance. One of the most significant limitations which was alluded to above, is the quantity of capable, experienced staff. Most of the communications services firms cited above will have some very capable personnel. However, the rate of growth in the use of true network communications and demands on the services of these firms will have them competing as heavily as the rest of business and industry for the required personnel. As a result, only a small fraction of the firms with significant information communications needs will be able to be properly satisfied by the services firms over the next five years.

Knowing we have challenges in solving communications problems on a timely basis with the current level of expertise, what are some of the solutions available to correct the situation?

IX. MAKING THE FUTURE A REALITY

Several actions must be taken to assure that a knowledgeable approach is taken in addressing the spectrum of needs of the business.

The key is to insure that senior management has an appreciation for the role of data communications in the success of the business. This must be approached on two fronts. First, to identify the exposures resulting from a program of status quo or "natural" growth in capability. Second, is to cite the mandatory and beneficial aspects of a considered communications plan and capability viewed in the context of the needs of the business.

The firm must acquire the expertise necessary to act as the catalyst in creating a functionally viable communications group or department. The quantities of personnel to staff the needs of business and industry are not currently available and will not be generally available for several years. Therefore, one key person is required. As stated earlier, the person is to be the catalyst to create, over time, the staff required. Finding the right person, however, is easier said than done. Where does one find the talent? There are three (3) principal sources:

A. Remote computing services companies

B. Large corporations

C. Hardware manufacturers

The best qualified individuals will be from the remote computing services firms and large corporations with one or more major data networks. Hardware manufacturers will have staff concerned with the communications hardware, software, and interfaces, and therefore, be reasonably knowledgeable of the elements required in developing a satisfactory data communications capability.

Communications is a service to be provided in support of internal user departments and external users/consumers of products and services of the company. Individuals who have had the benefit of obtaining their experience within a services company will already appreciate the role of the communications function. In addition, there will be a heritage of identifying a combination of elements, some not provided by the service company, with which to satisfy the company's communications needs.

Next is to develop the strategic requirements for data communications necessary to support the strategic plan for the business. Such a strategic plan for data communications should have a minimum of a five (5) year horizon and ten (10) years is very desirable. This effort should take no more than sixty (60) days and involve the key user organizations of the company.

Finally, and in many cases the action which causes the most controversy, is to alter the organizational placement of the function responsible for data communications and the control it is to have over company information communications solutions and services. This puts aside, for the time being, the issue of including both voice and data communications under this single function. The change in organization should, at a minimum, place the responsibility for data communications reporting to the manager/- director of data processing. Ultimately, which should be sooner than later, the function should be on a peer basis and reporting to the same senior management level as that of data processing.

This position assumes that responsibility for data communications is part of the information systems/services organization of the company. Information processing and information delivery systems must be managed under the same basic set of strategies to assure responsive services to the needs of the business.

X. SUMMARY

Throughout the world we now have ready access to virtually any size computer with available and functionally viable software. Applications are being developed at an ever-increasing rate. Traditional world economic powers are weakening and new ones are developing rapidly. Business and industry are adapting to these changing markets with increased international presence.

Information movement within a company and among businesses and industries worldwide, has not kept pace with the events cited above. Vision of the role of communications has been very late in coming. Now we are faced with a massive set of needs which require advanced solutions. Personnel with the capability and expertise to provide the required solutions exist in very limited quantities.

Communications needs will not be solved exclusively by turning them over to AT&T, GTE Telenet, Tymnet, SPC, MCI, SBS, XTEN, or any other current or planned service. In the foreseeable future, no one service will satisfy all of the needs relative to cost, function, and geography. Business and industry must have the internal expertise to select and manage the alternatives which can best satisfy their needs.

Specific actions have been recommended which will assure progress toward having the available expertise to insure that the information delivery systems of the 80's will be able to support the information processing systems which have been or are being developed. An individual company's success will be very much a function of the success and capability of its data communications systems which will be a function of the information communications expertise of the responsible personnel.

BANDWIDTH ROUTING IN X.25 NETWORKS

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Abstract

The concept of available bandwidth to each destination is used to establish routes and to control the flow of data in networks operated under the X.25 virtual circuit transport protocol. The Bandwidth Routing algorithm, a distributed algorithm which computes alternate paths and corresponding available bandwidth to each destination is presented and is illustrated with a simple network example.

1. X.25 Virtual Circuit Switching

The packet switching philosophy has undergone several modifications since its conception in the late sixties. The most radical changes (at least from the network transport protocol point of view) occured in the late seventies with the introduction of the X.25 CCITT recommendation for a standard interface protocol between user and packet network. [FOLT 78]

Early packet networks (e.g. ARPANET, Cyclades etc.) were designed under the assumption that the network should simply transport single packets (or messages) from source to destination in an efficient and reliable way. The notion that the packet may belong to a session, i.e. it may be part of a more or less steady stream of packets exchanged between users, was intentionally kept out ot the network. Consistently with this philosophy (which is commonly referred to as datagram philosophy), most of the internal network protocols and control procedures were designed to handle single packet (or single message) traffic. In particular, the routing algorithm was designed to find the minimum delay path from source to destination for a single packet, rather than the feasible path (or set of paths) to accommodate a data transfer of given bandwidth requirement.

The X.25 recommendation caused profound changes to this state of affairs. Under X.25, the network is required to keep a record of the various user sessions established through it. This implies that each session must be opened by a call set up procedure, and closed by a call clearing procedure, somewhat like in a circuit switched network. A virtual circuit is associated with each session at set up time. The entry and exit switch are required to monitor each virtual circuit: in particular they store the virtual circuit ID, the source and destination of the session, the delay and throughput class requirements (optional), and the flow control parameters. Sequencing of packets is maintained within each virtual circuit in the network access segments, and selective flow control is performed.

Strictly speaking, the X.25 recommendation requires that only the entry and exit switch support the virtual circuit protocol. Internally, the network can be managed using a datagram philosophy. Datapac, the Canadian public network has, in fact, followed this "hybrid" approach [MAGO 79]. The majority of the X.25 networks, however, have opted to extend the virtual circuit scheme to the entire network path. In this case, a fixed network path is assigned to each virtual circuit at set up time, and packet sequencing is maintained within each virtual circuit all along the path (and not only in the access segments). This philosophy is followed by Telenet [HOPD 78] and Tymnet [RIND 79] in the U.S., and by Transpac [SIMO 79] in France.

In virtual circuit networks, packets travel along the virtual circuit in a store-and-forward mode, being reassembled and checked for errors and, if necessary, retransmitted at each intermediate node. Several virtual circuits are generally multiplexed on the same trunk; thus, each virtual circuit must be distinguished from the others by a unique identifier, called virtual circuit number, which is stamped in the header of each packet travelling on that circuit. At each intermediate node a map translates incoming virtual circuit numbers into outgoing trunks. The map is updated each time a connection is set up or is cleared.

In comparing the virtual circuit scheme with the conventional datagram scheme we immediately recognize the following advantages of virtual circuit switching:

. the packet header overhead is reduced since the destination ID (which in a datagram consists of a string with destination node ID, destination Host ID and destination process ID) is replaced by a much shorter virtual circuit number.

. the routing overhead is reduced since routing decisions are made only at call set up

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This research was supported by ONR Grant N00014-79-C-0866 time, and routing messages do not need to be frequently exchanged between nodes as in the datagram case.

. no looping can occur since paths are fixed.

. the network can selectivey flow control traffic on a virtual circuit basis, since packets carry unique virtual circuit numbers.

. no packet reordering is required at the destination, before delivery to the Host, since packet sequencing is maintained withing the virtual circuit.

The virtual circuit scheme has also some drawbacks. The weakest point is probably the requirement of setting up a path for each connection. In transaction type applications, where the actual data transfer consists of only one inquiry and one response packet per session, the line overhead and delay introduced by the call set up procedure would be prohibitive. For connections of longer duration (such as, for example, a file transfer, or an interactive terminal-computer session) the overhead of the call set up phase is negligible with respect to the volume of data transferred during the active phase.

These observations lead the generally accepted conclusion that virtual circuit switching is better for long sessions and datagram is better for extremely short sessions. The best of all worlds is of course the integration of the two services. Indeed, standards for the integration of virtual circuit and datagram are now being prepared by CCITT for inclusion in the X.25 recommendation [FOLT 80].

Many of the existing packet switching protocols and control procedures were originally developed for early experimental networks which are datagram oriented (e.g. ARPANET, Cyclades). It is now necessary to review these procedures and verify whether they can be transfered to the new X.25 environment. In this paper we direct our attention to the routing control procedure. We define the desirable functions of a routing policy in a virtual circuit network, and propose a dynamic, distributed algorithm which can provide such functions. We then show that the proposed routing scheme can be efficiently combined with selective network access flow control.

2. Routing functions in a X.25 network

In an X.25 network we distinguish between two types of traffic requirements:

. steady flow sessions, which last for several minutes and are characterized by the average data rate in each direction of the connection. File transfers, remote program development, electronic mail, digitized speech, and facsimile are typical examples. We may assume that the average data rate is explicitely declared by the user at call set up time (using the throughput class option of X.25) or can be predicted by the network (based on terminal type, application type and measurement data).

. transaction traffic, where the session consists of the exchange of a few packets only. Typical example is the inquiry/response application.

Steady flow sessions are generally supported within the network by virtual circuits. Transaction packets are best carried as datagrams, using the datagram option available in the X.25 specifications.

Routing requirements are substantially different for these two types of traffic. The best route for an isolated inquiry packet may not necessarily be the same as the best route for the first of a long sequence of packets that are injected into the network at a steady rate. In fact, while in the first case we should simply minimize the single packet delay in order to optimize transaction response time, in the second case we must find a path that can support the steady flow without creating channel and buffer congestion. The routing of a virtual circuit is a relatively long term investment, since the path is fixed for the entire session. Therefore, more care is required in path selection for virtual circuit traffic than for datagram traffic.

The following requirements for a virtual circuit routing policy can be stated:

(1) datagrams should be routed on the minimum delay path.

(2) virtual circuits should be routed on the minimum delay path, among the set of paths which have sufficient average residual bandwidth to accommodate the incoming bandwidth request.

Conventional routing algorithms were designed to find the path which would minimize single packet travel time [McQU 72]. Recently, more sophisticated routing policies were developed, which attempt to minimize the average delay over the entire network by evenly distributing the traffice on several parallel paths [GALL 77]. In no case, however, an effort was made to match the incoming bandwidth request with the residual bandwidth available in the network.

Ideally, we would like to have, at each node, the information of the set of paths to each destination, and, for each path, we would like to know the average delay and the residual bandwidth available (in a statistical sense) on the path. Paths should be maintained in a list ordered by increasing delay and increasing available bandwidth. Note that the ordering must be strictly increasing for both delay and bandwidth since if two paths have equal delay, the path with larger bandwidth is always preferred to the one with smaller bandwidth (the latter path is said to be "dominated" by the former).

If this routing information were available at each node, datagram packets would be routed on the first path in the list (i.e. the minimum delay path), while virtual circuits would be routed on the lowest delay path which meets the bandwidth request.

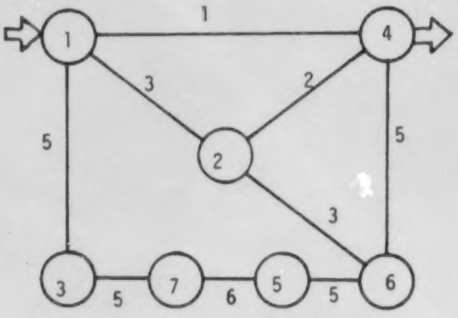
There are several ways in which this information can be assembled. In the following section we describe a distributed algorithm which constructs the path lists using distributed computation and periodic exchange of information between neighbour nodes. Distributed computation was chosen over centralized computation for reasons of reliability enhancement and line overhead reduction.

3. Bandwidth routing algorithm

The bandwidth routing algorithm is a distributed algorithm which finds all non-dominated paths between all node pairs, and ranks then by increasing delay and bandwidth. This section describes the format of the routing table structure stored at each node; the selection of the best feasible route; and the table update mechanism that follows the exchange of information between nodes.

3.1 Data Structure

Each node i(i=1,...N) stores a set of tables, one for each destination, listing the set of non dominated paths to that destination, ranked by increasing delay and bandwidth. In order to simplify the description of the algorithm, without loss of generality, we assume that delay is measured in terms of hop distance. Accordingly, paths are ordered by increasing hop distance and bandwidth.



Trunk labels represent residual bandwidth

Fig. 1 - Seven Node Network Example

Let us consider, as an example, the network shown in Fig. 1. For this network the routing and bandwidth tables residing at node 1 and containing paths to destination 4 are shown in Fig. 2.

Path	Routing Table		
	Hop distance	Residual bandwidth	Next node
(1,4)	1	1	4
(1,2,4)	2	2	4
(1,2,6,4)	3	3	2
(1,3,7,5,6,4)	5	5	3

Fig. 2 - Routing Table Format

In general, node i stores for each destination j a path list $L_{ij}=(H_1, B_1, R_1), (H_2, B_2, R_2)\ldots (H_k, B_k, R_k),\ldots (H_M, B_M, R_M)$ where M is the number of non-dominated paths to destination j. The value of M varies from case to case depending on network size and nodal connectivity. Experiments with networks of over sixty nodes have shown that the list of non-dominated paths tends to remain rather small. Case studies are reported in Sect. 7.

3.2 Route selection

Given that each node has an up-to-date routing table to each destination, the selection of the best route is done as follows:

(1) Virtual Circuit connection: upon receiving a virtual call request from the user, the entry node searches for the path with the least number of hops which can satisfy the bandwidth request. If a path is found, the call request packet is forwarded to next node on the path. The search for the best path is then repeated at each intermediate node, until, at the end, the active path from source to destination is traced. If no path can satisfy the request, the call is rejected. Alternatively, the entry node may inform the user that the call can be placed through the network with reduced throughput. If the user chooses to resubmit the call with reduced throughput, the network will meter the user's input rate, preventing it from exceeding the stipulated threshold.

(2) datagram packets: datagrams are generally routed on the minimum hop path. If such path is temporarily congested (e.g. queue length exceeds a given threshold), the path with next higher hop number (and, therefore, higher bandwidth) can be used, and so on. Thus, the list of available paths is used as a set of alternate paths on which to distribute the datagram load in case of congestion. Local routing based on alternate paths may lead to loops. In our case, however, endless loops can be easily prevented by requiring that non decreasing bandwidth path options be selected as the packet progresses in the network.

Referring to Fig. 1 and Fig. 2, we now illustrate the use of the routing tables with a few examples. Suppose a datagram packet must be sent from node 1 to node 4. The packet is transmitted directly to node 4 if the queue threshold on such link is not exceeded. Otherwise, the packet is sent to node 2. Next, assume that a virtual call request arrives at node 1 for destination 4, with average bandwidth requirement=2.5 units. The call is forwarded to node 2, and from here it will proceed to node 6 and then to node 4. Finally, let us assume that a call with bandwidth request = 10 and final destination 4 is presented to node 1. The call is rejected.

3.3 Routing table updating

Having shown the structure and the use of the routing tables we now proceed to explain how the tables are constructed and updated.

The routing update process is a distributed process. Simply stated, all the nodes carry out part of the computation in parallel. The individual results are then propagated throughout the network and are properly pieced together at each node so as to obtain the global solution, i.e., the complete set of non-dominated paths. This process goes on without stopping. It continuously refreshes the solution and provides automatic adjustments to topological changes, trunk load (long term) fluctuations, link and node failures, routing message errors (losses) etc.

In order to carry out the distributed routing update process, each node periodically transmits to its neighbors the contents of its routing table. To be precise, the node needs to transmit only the B and H value for each path on each list. The R value is not transmitted.

Each node constructs a new path list for each destination based on the path lists received from the neighbors. The steps of this construction are outlined below. For simplicity, we assume that the node awaits until all the path tables from the neighbors are received before carrying out the update. A straightforward modification of the basic algorithm allows asynchronous updating as the information is received from each neighbor.

Step 1. Update received path lists
Let node 1 be the node at which the routing table is being constructed. Suppose node 1 receives from neighbour k the path list $L_{kj} = (B_1, H_1), (B_2,H_2),\dots(B_i, H_i),\dots(B_M,H_M)$ i.e. the list which contains the paths from k to destination j. The list is updated as follows:

```
|
|$B_i \longleftarrow \min(B_i, \mathrm{resbw}(1,k))$
|
|$H_i \longleftarrow H_i + 1$
|
```

where resbw (a,b) is the residual bandwidth on a trunk from node a to node b. Residual bandwidth is computed by averaging the utilization of a trunk over a properly chosen history interval, and subtracting average traffic from trunk capacity.

After this operation, eventual dominated solutions contained in the tail of the path list are purged. Note that this update preserves the strictly increasing order of H and B values in the path list. The updated path list represents bandwidth and hop values of the non dominated paths from node 1 to destination j, going through node k.

Step 2. Merging updated lists
At this stage node 1 has a set of updated path lists to destination j, one for each neighbour k, (k=2,...n):

$$L_{2j}=(B_1,H_1),(B_2,H_2),\dots$$
$$L_{kj}=(B_1,H_1),(B_2,H_2),\dots$$
$$L_{nj}=(B_1,H_1),(B_2,H_2),\dots$$

In order to construct the final path list, these lists are merged in order of increasing Hop value. This can be efficiently done by using scanning pointers, one for each list, initially assigned to the first path in each list. At each step, the path with smallest hop value is selected among the pointed paths, and the pointer is advanced. If two or more paths have the same (minimum) hop value, the path with largest available bandwidth is selected. If bandwidth values are also identical, an arbitrary choice is made. The selected path is added to the final list, if it is not dominated (i.e. its H and B values are strictly larger than the corresponding values of the previously selected path). Otherwise, it is discarded.

Initially, when a node is brought up in the network all of its path lists are empty except for the list to itself as a destination. The self-list contains only one path, with H=0 and B=∞. After initialization, nodes start exchanging routing tables periodically, and path lists start filling up. The steady state solution is reached in a number of updates which is equal to the number of hops on the longest, maximum residual bandwidth path between any pair of nodes. Since the maximum bandwidth path cannot contain loops, an easy upperbound on the number of updates is N-1, where N = number of nodes in the network.

In order to illustrate the update and merging procedure, we consider the network example in Fig. 1 and carry out the routing computation from node 1 to node 4, after node 1 has received the path lists to destination 4 from all of its neighbors.

Path lists received from neighbours 4, 2 and 3 respectively (note: pairs represent B and H respectively):

$L_4=(\infty,0)$

$L_2=(2,1),(3,2)$

$L_3=(1,2),(2,3),(5,4)$

After the update step we have:

$L_4=(1,1)$

$L_2=(2,2),(3,3)$

$L_3=(1,3),(2,4),(5,5)$

After the merge step we have (note: triples represent B, H and R respectively):

$L_1=(1,1,4),(2,2,2),(3,3,2),(5,5,3)$

This is the same solution that was shown in Fig. 2. Note that the first two paths of the list received

from node 3 are eliminated since they are dominated by other paths.

4. Full Duplex Virtual Circuits

The Bandwidth Routing algorithm establishes one-way circuits from origin to destination. Since virtual circuits are full duplex circuits, after the destination is reached the algorithm must be used once again to establish the return path from destination to source (note: the return path may differ from the forward path). It may occur, however, that the call be blocked on the return path if no sufficient bandwidth can be secured to accommodate the outbound rate (in spite of the fact that a feasible forward path was found). This situation may occur when a terminal user opens a connection to a remote Host computer to locally display or print a file. The inbound rate is low (traffic merely consists of control and acknowledgment messages), thus a feasible path is likely to be found. The outbound rate, on the other hand, is substantially higher. Therefore, the return request may be rejected. Return path blocking is clearly undesirable, since time and resources have been already invested in establishing the forward path.

If we assume that the average bandwidth request of a virtual circuit for both inbound and outbound direction is known at the origin node (i.e., it is declared by the user, or it is estimated by the network), then, return path blocking can be avoided by storing at the origin node the information on the maximum bandwidth available on the return path from each destination. The origin node could then check for feasibility of both inbound and outbound rate at call set up time, and would forward the call only if both directions of the connection are feasible.

It turns out that a simple extension of the Bandwidth Control algorithm provides also the maximum bandwidth information on the return path. Namely, each node, say i, is simply required to store the maximum return bandwidth $MRB_i(j)$ from node j, ($j=1,2,\ldots,N$). Periodically, node i will transmit to neighbor node n its path lists, as prescribed by the Bandwidth Control algorithm. At that time, it will also transmit the value $MRB_{in}(j)$, ($j=1,2,\ldots,$), where:

$$MRB_{in}(j)=\min(MRB_i(j),\ resbw(i,n))$$

where resbw(i,n) is the residual bandwidth on a trunk from i to n. The value $MB_{in}(j)$ thus represents the maximum bandwidth available from j to n going through node i.

Node 1, upon receiving from each neighbour k (k {2,3,...,N}) the value $MRB_{kl}(j)$, will update its value $MRB_l(j)$ as follows

$$MRB_l(j) = \max\ (MRB_{kl}(j))$$

Initially, we set:

$MRB_i(j)=0$, for $i \neq j$

$MRB_i(j)=\infty$, for $i=j$

Convergence properties are identical to those of the Bandwidth Routing algorithm.

5. Overhead considerations

In a dynamic routing algorithm we are concerned with three types of overhead, namely: processing O/H, line O/H and memory O/H. If we assume that a one-byte field is sufficient to store a hop distance or residual bandwidth value, or a node ID number, we have the following expressions for the three types of overhead:

Line O/H (on each direction of a trunk) =2MN/t (bytes/sec)

Processing O/H (for each node) = 2MN/t (instructions/sec)

Memory O/H (for each node) = 3 MN (bytes)

where:

N = number of nodes in the network

M = average number of non-dominated paths to each destination

t = update period

We note that all O/H expressions are linear in M. As pointed out earlier, the value of M was found to be typically very small (less than 3 or 4) in a number of experimental investigations. This means that the number of non-dominated paths is only a small fraction of the number of all distinct paths existing between a given source-destination pair.

Although the average value of M over the entire network is very small, there may still be some "pathological" node pairs in the network, between which the number of non-dominated paths in relatively high. For example, in a 60 node network experiment with average M=2 we found a node pair with 10 paths. In order to simplify the routing program implementation and use uniform size routing tables, it is possible to construct a "truncated" version of the algorithm, in which the routing tables are truncated if they exceed the maximum size M_{MAX}. A truncated table contains only the $M_{MAX}-1$ first paths of the original table, plus the path of maximum residual bandwidth. It can be easily shown that a simple modification of the alogithm in Sect. 3.3 produces consistent truncated tables throughout the network.

Line and processing O/H is critically sensitive to the update period t. Therefore, t must be judiciously selected for best network performance. Clearly, the smaller t, the more responsive the algorithm is to traffic fluctuations. However, the smaller t, the higher the O/H. A good compromise is reached by setting t to be much smaller than the average duration of a virtual circuit connection (typically, on the order of several minutes), and larger than the history window over which traffic is averaged for available bandwidth computation (typically, on the order of seconds). Therefore, the optimal update period should be on the order of several seconds in typical X.25 networks.

6. Impact on flow control

Bandwidth routing has impact on flow control in that it finds not only a low delay path, but also a feasible path, i.e. a path which can accommodate the incoming call without causing congestion. Unfeasible requests are detected at the network entry point and are either rejected or reduced to fit available resources.

In this respect, bandwidth routing can be viewed as a form of network access flow control [GERL 80]. We recall that network access flow control mechanisms have the purpose to throttle external inputs based on measurements of internal network congestion. Congestion measures are, in this case, selective in that they reflect the congestion of a path leading to a given destination. Another selective network access flow control scheme recently reported in the literature was the "Choke Packet Scheme" proposed for the Cyclades network [MAJI 79]. In that scheme, congestion information (a binary variable) is propagated in the network together with shortest path routing information. The bandwidth routing scheme is more powerful than the Choke Packet Scheme in that it monitors the actual value of available bandwidth, and keeps track not only of the shortest path, but also of all non-dominated paths to each destination.

In order to illustrate the advantages of bandwidth routing over conventional routing, let us assume that a call with requirement exceeding network capacity is presented to a network controlled by a conventional (say, ARPANET type) routing algorithm. In the conventional network, the call is initially accepted without any warning. After data transfer begins, congestion quickly builds up on the path. At this point, hop level flow control mechanisms, such as selective backpressure on individul virtual circuits, are invoked to restore smooth operation [GERL 80]. Two problems, however, arise in this approach. First, unfairness may derive since the newcomer may, under some conditions (e.g. shorter hop distance from source to destination, larger window size, etc.) "squeeze out" existing users. Secondly, and more importantly, the bandwidth that the network can provide to the newcomer may itself not be sufficient for the proper operation of the new connection. For example, if a digitized speech connection normally requiring 9.6 kbps bandwidth is accepted when the (statistically) available bandwidth in the network is only 4.8 kbps, an intolerable quality degradation will occur. The user will then repeatedly hang up and dial again, only to aggravate the situation. Bandwidth routing would completely eliminate this problem by recognizing and rejecting unfeasible calls at the network entry point.

7. Experimental Results

A Bandwidth Routing algorithm simulator which carefully reproduces the routing table update mechanism and the allocation and deallocation of virtual circuits was written in the programming language C and was run on a DEC VAX computer. Logical correctness of the routing computation and convergence properties of the algorithm were experimentally verified. An important objective of our experimental investigations was the study of routing table size as a function of network parameters. As we mentioned earlier, the size of the routing lists plays a crucial role in determining storage and processing overhead of the proposed scheme.

The number of entries per routing table list (i.e. the number of non dominated paths to a given destination) is expected to depend on three key factors: (1) granularity of the bandwidth allocation (i.e. th ratio between trunk speed and minimum bandwidth increment); (2) number of nodes; and, (3) topological connectivity. In our experiments, we considered five ARPA-like topologies with number of nodes varying from 10 to 60 nodes. The degree of topological connectivity was kept fixed throughout the experiments (this detracts little from the general validity of the results since ARPANET connectivity is representative of most of the existing commercial networks). Bandwidth granularity varied from 6 to 61; namely, considering that ARPA trunk speeds are 50 kbps, bandwidth allocation increments varied in the range from 1 kbps to 10 kbps. For a given network topology and bandwidth granularity several trunk bandwidth allocations were randomly generated and were submitted to the Bandwidth Routing simulator. For each allocation, the bandwidth routing tables were generated. Several statistics were derived from these results. In particular, tables 1 and 2 show average and maximum number of entries per routing table list (average and maximum are over all node pairs and over all the experiments).

	Nodes in network				
Bandwidth Granularity	10	15	24	34	60
6	1.39	1.38	1.22	1.26	1.43
11	1.44	1.45	1.33	1.43	1.66
16	1.42	1.53	1.40	1.49	1.81
21	1.46	1.56	1.40	1.54	1.84
26	1.48	1.58	1.42	1.54	1.90
31	1.47	1.59	1.47	1.58	1.94
36	1.48	1.61	1.46	1.61	1.96
41	1.49	1.61	1.50	1.62	1.97
46	1.49	1.63	1.49	1.64	1.99
51	1.49	1.64	1.49	1.62	2.01
56	1.50	1.67	1.50	1.65	2.01
61	1.50	1.64	1.48	1.65	2.04

Table 1 - Average number of entries per routing table list.

Bandwidth Granularity	Nodes in network 10	15	24	34	60
6	4	4	4	4	5
11	4	5	4	5	6
16	4	5	5	5	7
21	4	5	5	5	7
26	4	5	5	5	7
31	4	5	5	5	7
36	4	5	5	5	8
41	4	5	5	5	8
46	4	5	5	5	9
51	4	5	5	5	10
56	4	5	5	6	9
61	4	5	5	5	8

Table 2 - Maximum number of entries in routing table list

From the results we note that the number of non dominated options is surprisingly small (on the average we have between one and two options available). Furthermore, maximum table size is 10, which is much smaller than the number of all possible paths between arbitrary pairs in a 60 node network. These results confirm our conjecture that dominacy would drastically reduce the number of feasible options. They demonstrate that the Bandwidth Routing algorithm is manageable from both memory and processing point of view.

To give an idea of the nature of the solution, fig. 3 shows a 60 node topology with randomly assigned link residual capacities ranging from 1 to 61. Links are full duplex, with a different value of capacity in each direction. In the figure, link capacity labels correspond to a clockwise convention for the orientation of the two half-duplex links on each trunk. The five non dominated paths from node A to node Z are shown together with their respective hop and bandwidth values.

8. Conclusion

We have shown that conventional routing schemes are not adequate for X.25 virtual circuit networks, where the problem of delivering an isolated packet to destination as quickly as possible is replaced by the problem of finding an efficient and safe path for the stream of packets which form the user session. A satisfactory routing algorithm must be capable of matching the bandwith requirement of each session (the requirement may be posted in the X.25 call request packet as a "throughput class" parameter) with the bandwidth resources available in the network.

In this paper, we have proposed a new algorithm for X.25 virtual circuit operation, the Bandwidth Routing algorithm, which provides at each node the up-to-date information of the alternate paths to each destination together with the bandwidth available on each path. The algorithm is base on periodic updating and distributed computation, and therefore is robust to network failures and can adjust to traffic fluctuations. The routing tables constructed by the algorithm allow the routing of virtual circuits on feasible paths, and provide a convenient set of alternate paths for the routing of datagram traffic.

Bandwidth routing operation has also a beneficial impact on flow control, and can be viewed as a powerful complement to network access flow control schemes.

Acknowledgments

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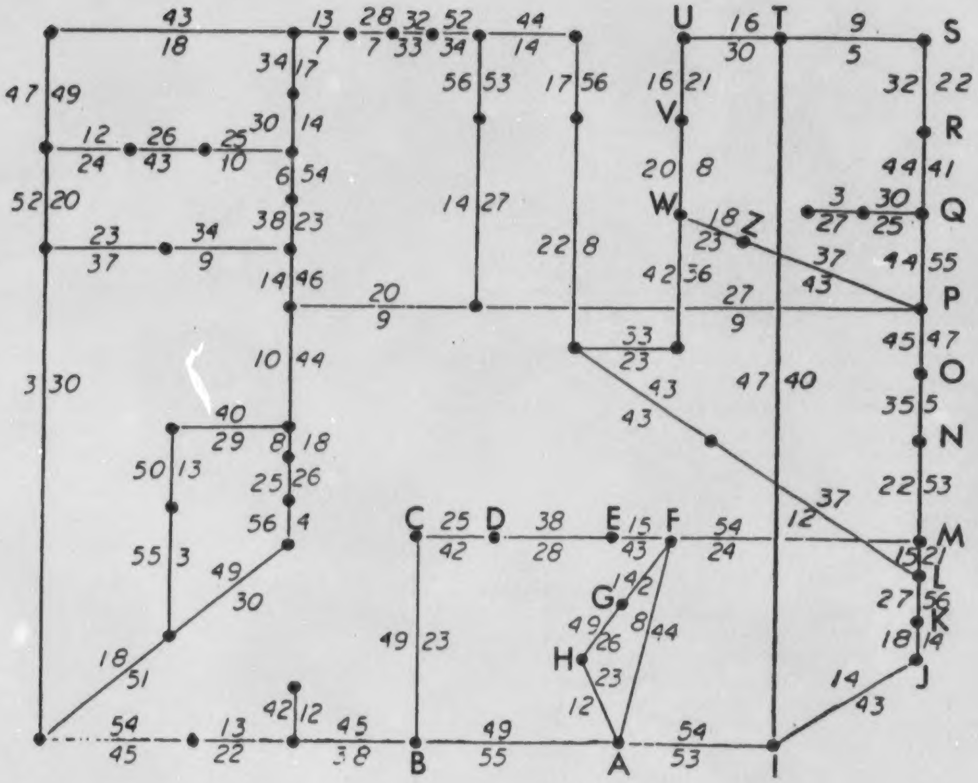

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18
14
H
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51
14
43
12
42
12
54
45
13
22
45
38
B
49
55
A
54
53
I

		Hop Length	Bandwidth
PATH 1:	A I T U V W Z	6	8
PATH 2:	A I T S R Q P Z	7	9
PATH 3:	A H G F M N O P Z	8	12
PATH 4:	A I J K L M N O P Z	9	14
PATH 5:	A B C D E F M N O P Z	10	15

Fig. 3 - Non dominated paths from A to Z

An Overview
of
The MX Command, Control & Communications System

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Abstract

The MX Command,Control and Communications (C^3) System will be one of the largest fully encrypted networks in the world. In excess of 5,000 computers at more than 4,800 sites will be linked together allowing rapid acquisition of status data and rapid dissemination of Command and Control (C^2) information. This paper provides an overview of the major C^3 subsystems; Fiber Optic Cable Data Network, MF Radio Network, Maintenance and Security Voice Network, Higher Authority Communications, and Command and Control Subsystem.

1. INTRODUCTION

The MX C^3 system architecture is based on requirements to provide secure, reliable, flexible, and timely pre- and post-attack control and communications capability for the MX wing. Figure 1 depicts the Horizontal Shelter Site - Separate Transporter and Mobile Launcher Generic concept. During pre-attack, there is a large volume of information traffic between the various manned and unmanned nodes. This traffic includes status information necessary to assure weapon system readiness, safety, and security; and commands and data required for positive system control, testing, targeting, and launch. Wing security features include encryption of all data and voice traffic; super-encryption of and restricted access to launcher data; controlled access to all nodes; and horizontal shelter physical security monitoring. The element that distinguishes the MX weapon system from all previous systems is the Preservation of Location Uncertainty (PLU). That is, keeping the location of all missiles secret under all situations is fundamental to the MX concept. Every element of MX design has PLU as a driving factor, the C^3 system as designed by GTE will keep the number of persons with location knowledge to an absolute minimum.

2. SUBSYSTEMS DESCRIPTIONS

2.1 CABLE DATA NETWORK

The Fiber Optic (FO) Cable Data Network (CDN) provides secure, reliable, pre-attack communications for the MX Wing. The CDN is required to interconnect the two (2) Operational Control Centers, the four (4) Area Support Centers (ASCs), the forty-six hundred (4,600) Horizontal Shelter Sites (HSSs), and the two hundred (200) Cluster Maintenance Facilities (CMFs) such that failure of a single site (OCC, ASC, HSS, or CMF) does not cause cable communications isolation of any other operating site. Further requirements stipulate that the connectivity of the cable network be such that coexisting failures of two or three stations and/or cable links do not isolate more than one cluster/launcher, a cluster being 23 HSSs and one CMF.

The connectivity of the CDN is a three tier, hierarchical structure as illustrated in Figure 2. At the lowest level, 23 HSSs and one CMF are linearly connected to form a cluster. Within the cluster, each HSS is connected to its adjacent HSSs or CMF by a full-duplex fiber optic cable to form a string of 24 sites (23 HSSs and one CMF). The string of sites is terminated at one end by the HSS that is designated as a concentrator and at the other end by the CMF, which also functions as a concentrator. A CMF has essentially the same hardware components and software functions to perform as an HSS, but is housed in a soft facility. A concentrator is an HSS configuration with additional fiber optic interfaces and additional processing functions to perform.

The second tier of this hierarchical network consists of the interconnection of these 200 clusters and the 4 ASCs. The HSS concentrators of each of the 200 clusters are connected to form one complete loop while the CMF concentrators are connected to form a second concentric loop. The four (4) ASCs, which consist of two (2) communications controllers each, are positioned within the loop so as to split the loop into four equal parts consisting of fifty (50) clusters each. Each of the ASC communications controllers is tied into a separate loop with communications being provided between the controllers by a common full-duplex link. In essence, each ASC has been made to look like a cluster with the communications controller functioning like cluster concentrators with no HSSs in the string.

GTE

MX C³

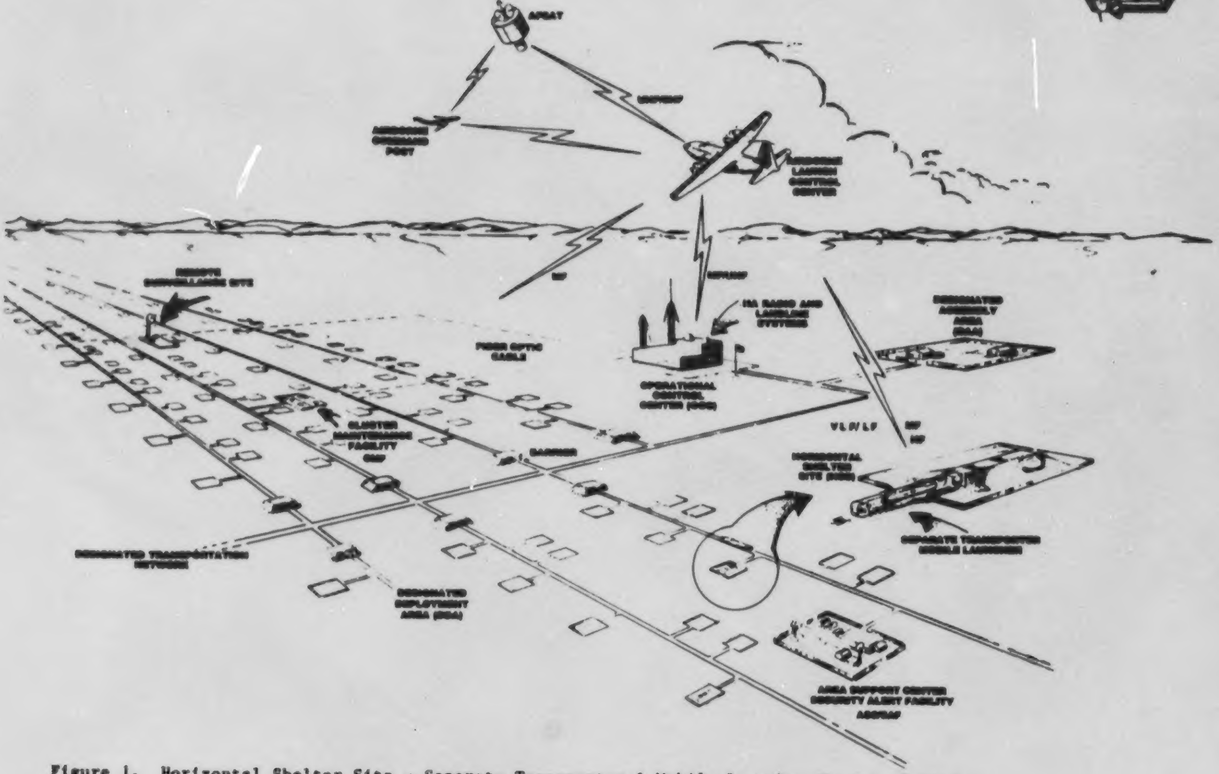
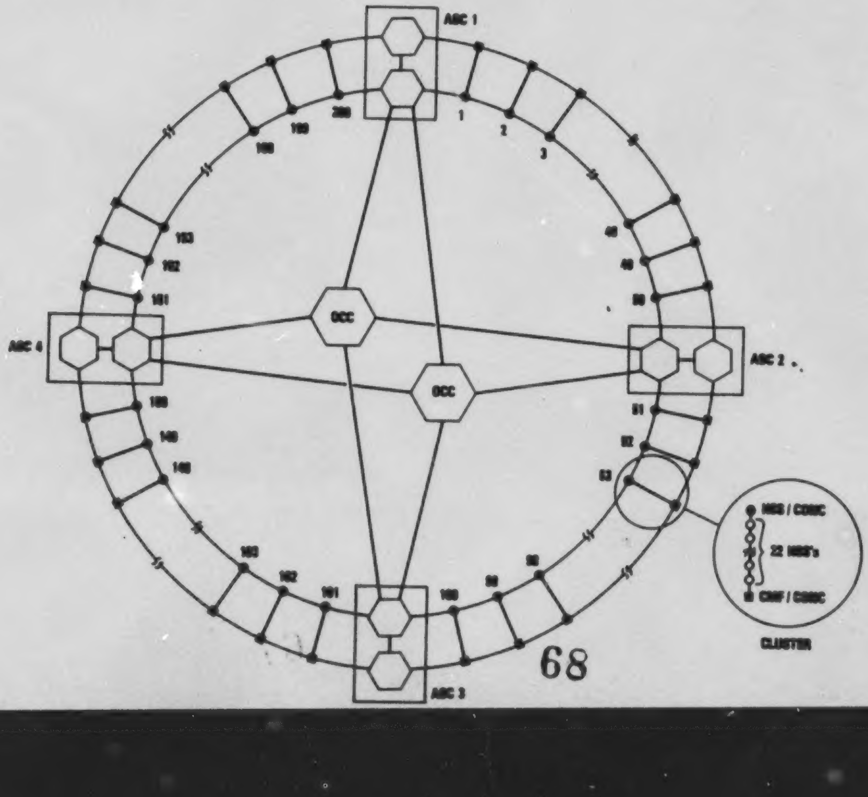

AFSAT
AIRBORNE COMMAND POST
AIRBORNE LAUNCH CONTROL CENTER
REMOTE SURVEILLANCE SITE
FIBER OPTIC CABLE
ISA RADIO AND LANDLINE SYSTEMS
DESIGNATED ASSEMBLY AREA (DAA)
OPERATIONAL CONTROL CENTER (OCC)
CLUSTER MAINTENANCE FACILITY CMF
BARRIER
VLF/LF
HF
HORIZONTAL SHELTER SITE (HSS)
SEPARATE TRANSPORTER MOBILE LAUNCHER
DESIGNATED TRANSPORTATION NETWORK
DESIGNATED DEPLOYMENT AREA (DDA)
AREA SUPPORT CENTER SECURITY ALERT FACILITY ASC/SAF

Figure 1. Horizontal Shelter Site - Separate Transporter & Mobile Launcher Generic Concept


ASC 1
200
199
198
1
2
3
153
152
151
48
49
50
ASC 4
OCC
OCC
ASC 2
150
149
148
51
52
53
103
102
101
100
99
98
ASC 3
HSS / CDSIC
22 HSS's
CMF / CDSIC
CLUSTER

The third and highest tier of the hierarchical network consists of the two OCCs. Each of these two sites connects to one of the communications controllers in each of the four ASCs. It doesn't matter if these connections are made to the ASC communications controller on the CMF concentrator loop or the HSS concentrator loop, so long as all connections are made to the same loop. If the connections were made to different, alternating or random loops, the software in each controller would, to some extent, have to be unique because of the different perspective each would have of the Wing.

The connectivity described above meets the requirements to minimize the deployment costs of the MX Wing by minimizing the redundant connectivity required to meet the isolation requirements under failure conditions. Further cost reduction is realized if each cluster is connected to its next closest cluster on either side and the road network is laid out judiciously keeping the Cable Data Network in mind.

This connectivity also has several added benefits which are not directly related to requirements. Among these are the connectivity of the manned sites (OCCs/ASCs) and the number of HSS/CMF hardware/software configurations. The connectivity shown provides a near direct link between all manned sites such that large volumes of data may be passed between these sites with a minimum impact on the Cable Data Network. Also, with this connectivity, the number of hardware/software configurations at the HSS/CMF is limited to two: the normal intra-cluster configuration and the concentrator configuration. The configuration required to connect the OCCs to the network is provided by the ASCs rather than by a third HSS configuration.

2.2 MF RADIO

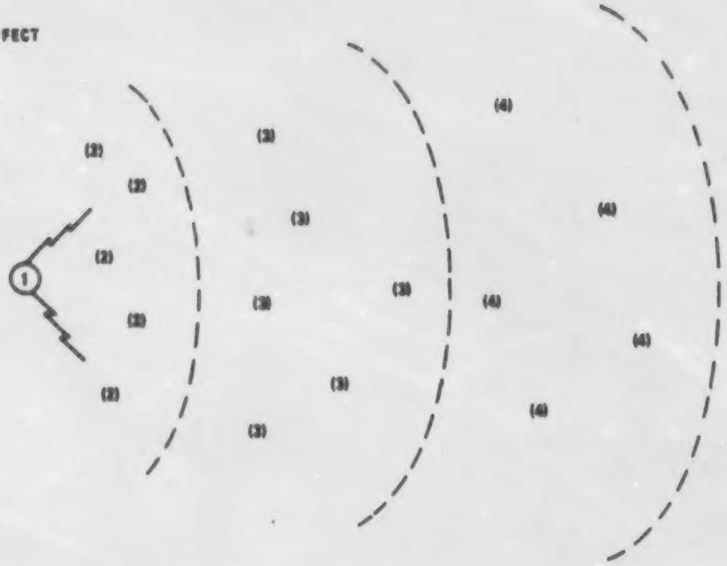
The MF Radio Network provides direct communications between Launchers, the OCCs and the Airborne Launch Control Centers (ALCCs). During post-attack, it is the principal means for the transfer of data and command messages between the surviving launchers and the ALCCs. During the pre-attack time period, the MF radio units located at the manned OCCs have the capability to communicate with the ALCCs. Limited transmission and reception capabilities are planned for all ground facilities housing launchers for test/checkout and possible emergency usage.

The basic protocol for message propagation is a time slotted multiple (simultaneous) transmission scheme considered as a simulcast technique. In its simplest form, simulcast propagates messages through the network in a broadcasting mode with radio terminals situated farther and farther away from the originator sequentially participating in the message transmission until they have all received the message. The terminal initially having a message to transmit must first access the network; this is necessary so that other terminals will be receiving its message when it transmits and no other terminals will be transmitting a different message at the same time. The message may be generated at any time. This results in a random time delay before the message can be transmitted by the terminal depending on the particular multiple access scheme. Upon transmission, some other terminal in the network will receive the message correctly. The number of terminals in the network receiving the message correctly will depend on several factors; modulation and coding technique used, particular noise conditions during transmission time, the presence of jamming and interference, and the geographical placement of the transmitter and other terminals. All of these factors will determine how wide an area is covered by the first transmission. A terminal that has correctly received the message and validated its authenticity will then immediately retransmit it in the next time slot. Geographically separated transmitters will then send the same message, covering a wider area than the first transmission has covered and acting as relays to stations farther away.

The simulcast system is a form of TDMA discipline, within which a launcher that receives a message in one slot repeats it in the next slot. This sequence is called a simulcast hop and a message that is transmitted across the network in N slots is said to require N hops. A pictorial representation of the process is illustrated in Figure 3. Typically, an actual TDMA protocol will limit the number of hops available to cross the network. This limit is chosen so that the selected system will attain the prescribed reaction times with a 95 percent probability.

The main idea of simulcast then is that the communications links are not pre-established, but are set up when the transmission is made. For a dense enough network where many terminals exist and for a wide enough transmission range, simulcast provides great reliability of message throughput. The network is insensitive to the loss of individual links, which may occur due to terminal destruction or malfunction, or particularly bad channel conditions. This flexibility provides the network with high survivability and low vulnerability to jamming. This high survivability is provided by a protocol which does not depend on pre-established links to route a message to its destination. The message will take all paths within the radius of propagation of the transmission. If this radius of propagation is large enough to reach a substantial number of radio terminals, the probability of correct message reception by at least one of these terminals is very high. The success of the simulcast concept, then, depends in part on maintaining a large enough radius of propagation.

- RIPPLE EFFECT



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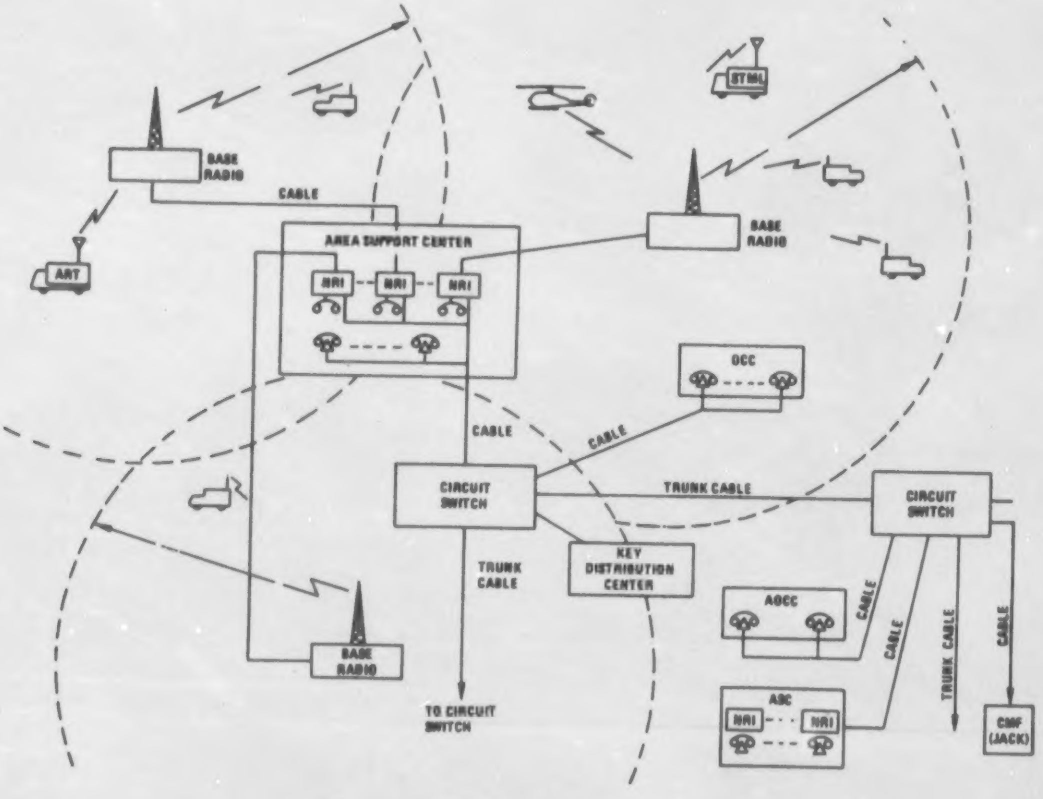
- TRANSMISSION UPON RECEPTION
- TIME SLOTTED OPERATION

Figure 5. Simulcast Relay



BASE RADIO
CABLE
ART
AREA SUPPORT CENTER
NRI
NRI
NRI
STML
BASE RADIO
DCC
CABLE
CABLE
CIRCUIT SWITCH
TRUNK CABLE
CIRCUIT SWITCH
TRUNK CABLE
KEY DISTRIBUTION CENTER
BASE RADIO
TO CIRCUIT SWITCH
AOCC
CABLE
CABLE
TRUNK CABLE
CABLE
ASC
NRI
NRI
CMF (JACK)

Figure 6. M & S Voice Concept Diagram

The simulcast network connectivity is very flexible since links are established during transmission. A disadvantage of this technique is that only one message at a time can exist in the channel being monitored by the receiving stations. When a Launcher transmits a message, all Launchers within its propagation radius must be monitoring that channel in order to receive and repeat the message. Since the stations operate in a half-duplex mode, the protocol is such that no messages are expected when a station is transmitting.

2.3 MAINTENANCE AND SECURITY VOICE NETWORK

The Maintenance and Security (M&S) Voice Network provides switched secure voice communications to maintenance and security forces in the MX Wing Designated Deployment Area (DDA). The M&S Voice Network, which consists of an automatic switched telephone cable network and interconnected VHF mobile radio networks is depicted in the M&S Voice Network concept in Figure 4. The M&S Voice Network consists of static and mobile user terminals, a fiber optic cable network, digital voice switching centers, mobile radio access base stations, and a remote key distribution center.

Voice channels use 16 Kbps digital voice signals which are encrypted to provide communications security. Switching centers are strategically located to reduce cable plant are interconnected by time division multiplexed trunk groups. Subscriber loops are also multiplexed to reduce loop transmission costs. The M&S digital voice switches are SB3614-TD (MX) automatic 90-line switches. The SB3614-TD (MX) provides switched services to KY 68/78 digital secure voice terminals and KY-90 digital secure network radio-cable interface units. The switch provides essentially non-blocking service to the 90 subscriber lines and trunks.

The relatively smooth plains in the DDA are generally dotted with isolated hills and mountain peaks. VHF radio/antenna sites must often be located within short distances to eliminate radio dead zones. Based upon this topography and the data from analyses performed using the Longley-Rice models, an effective VHF Radio range of 20 miles was selected as the basis for estimating the quantity of radio networks in the DDA. The radio sites are remotely controlled from the ASC where each radio network control position is equipped with a KY-90 digital radio network cable interface unit to provide access to the M&S voice switched cable network. The digital net radio-cable interface is automatically controlled in the M&S Voice Network.

2.4 HIGHER AUTHORITY COMMUNICATIONS

Effective command and control of the MX system is achieved through the utilization of landline and radio frequency channels that establish communication links between higher authority and the MX Wing. Potential higher authority sources with which MX must interface include NEACP, CINCSAC, CINCLANT, PACTACAMO, SATXOM, ERCS, PAS, SACDIN, and STN.

Initially, higher authority will interface with the OCC in the pre-attack time frame. During the trans- or early post-attack periods, it is envisioned that the ALCC will inherit command and control from the OCCs and must interface with higher authority.

2.5 COMMAND AND CONTROL SUBSYSTEM

The prime MX mission function in pre-attack is to maintain system readiness. To accomplish this, each system node routinely assembles its own operational and equipment status for transmission to the Launch Control Center (LCC). In pre-attack, the fiber optic cable data network serves as the communications link for this status information. At the Launch Control Center, this information is first processed to prevent display or dissemination of missile/launcher location. Operational status is then displayed in the Launch Control Center. Other status, namely physical security status from the HSSs and other remotely sensed security data is distributed to the Wing Security Center, which is also located in the OCC. Similarly, maintenance status data is distributed to the Maintenance Control Center. Because the Launch Control Center is the controlling element in the MX OCC, it is responsible for the coordination and authorization of Wing C^3 activities. Indication of a fault in a status message from a system element will initiate automatic fault detection and isolation at the OCC. The Launch Control Center must control and/or participate in this function at least initially in order to protect missile location data. Once this is done, the LCC can hand over the status information for further processing and action to the Maintenance Control Center. However, the Launch Control Center will monitor maintenance operations and will control initiation of shelter access commands. The LCC will also retain the responsibility during maintenance, of routine Preservation of Location Uncertainty (PLU) maneuvers, to prevent missile location information from being displayed or distributed. The LCC will also periodically conduct and evaluate system and system readiness tests. These may include tests of the MF radio subsystem, the airborne launch control capability, physical security subsystem response, cable network response, or higher authority communication links.

The C^2 subsystem is responsible for conducting missile targeting and launch. Target data, target biasing data, execution plans, target assignments, launch times, and other SIOP data for MX are received at the LCC from higher authority and distributed to the launchers under control of the LCC by means of commands or the remote data transfer protocol using the fiber optic network. At the launcher target constants are generated and stored by the Launcher C^2 processor for transmission to and use by the missile in response to commands from the LCC. Any changes in targeting parameters must be authorized and initiated by the LCC. Launch orders issued by higher authority are processed by the Launch Control Center using secure codes stored in the center. A launch command is initiated under two-man control at the LCC and distributed via the cable or MF networks to the appropriate launcher or launchers. Launchers are provided with a method that allows each launcher to process launch commands addressed to it. As in all commands initiated by the LCC, command receipt and effectivity is acknowledged through status reporting.

Pre-attack wing security is supported by the C^2 subsystem. HSS physical security data is sent to the OCC as part of the routine status collection cycle where it is processed in the LCC and displayed in the Wing Security Center. That HSS security status data is also distributed to and displayed at Area Support Centers. At the ASC, C^2 equipment controls Remote Surveillance Sites that collect radar information which is returned to the ASC for display. Additional system security responsibility of the C^2 subsystem includes control of the distribution of the codes used in launch operations and key variables used by the C^2 subsystem to provide secure encrypted communications in the cable and MF radio communications networks.

During pre-attack operations, updated wing operational status is provided to the ALCC by the Launch Control Center in the OCC. The OCCs and ALCC exchange messages to assure that positive control of the MX Wing is maintained by the MX manned control centers for as long as they survive. In post-attack operations, loss of both OCCs will cause the ALCC to assume wing command and control responsibility. The Launcher will transfer command and control responsibility to the ALCC also. This transition will occur automatically at the launchers since the OCC Launch Control Centers normally issue periodic commands to the launchers that verify that the OCC LCC is alive and in command of the wing. Receipt of this command by the launcher prevents the launcher from acting upon any command received from the ALCC. The ALCC, in turn, will issue its own keep-alive messages. The launcher C^2 processor will turn the MF radio "ON" to provide and/or relay ALCC messages. The ALCC has the responsibility for controlling targeting and launch in post-attack. The ALCC may also interrogate the launchers in order to determine their status. In post-attack, as part of the targeting/launch operations, the launchers may be commanded to self-optimize their target selections. Launcher status of each of the surviving launchers is distributed wing wide to support self-optimization. The launchers may then select optimum target sets to assure that the highest priority targets are included in the repertoire of the portion of the wing which survives.

3. SUMMARY

The MX C^3 subsystem has been designed to meet system requirements. The CDN concept guarantees a network that is reliable, responsive, simple to implement in software, straightforward to maintain, and attentive to cost constraints. The MF Radio concept exploits the state-of-the-art to provide the best attainable post-attack performance under adverse environments, within power and cost constraints, without relying on any high risk development. The M&S Voice Switched Network is a cost effective and optimal approach. The HA Communications will achieve and maintain connectivity of HA with the MX Wing. And the C^2 subsystem provides mission critical command and control functions, interfaces to MX communications, coordination of maintenance and security functions to prevent interference with launch capability, and orderly transition of MX wing control from the OCCs to the ALCC(s) to higher authority directly.

4. ACKNOWLEDGEMENT

This paper would not have been possible without the extended and sometimes heroic efforts, over the past eight months, of the many individuals in the various engineering and support departments of the Strategic Systems Division of Sylvania Systems Group. We take this opportunity to thank those individuals whose efforts have made this paper possible.

DATA INTEGRITY IN DATA COMMUNICATIONS WITH DUMB TERMINALS

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Abstract

With the rapid growth of minicomputers and their associated 'dumb terminals' in data communications, consideration must be given to providing some form of insuring data integrity. The large mainframes have their various protocols for this purpose. We will discuss here what is available to the minicomputer user.

In order to maintain data integrity in data communications between terminal and computer, it is vital that some type of error control protocol be used. Several new protocols have been introduced recently in an attempt to establish a generally acceptable standard: IBM has developed Synchronous Data Link Control (SDLC); an international standard now exists known as the High-Level Data Link Control (HDLC); and there is now a Federal or ANSI Standard called Advanced Data Communications Control Procedures (ADCCP). But all these protocols are inapplicable to the 'dumb terminal' user, and hence to most minicomputer users. The benefits which they provide, however, may be obtained by using external, standalone 'black boxes' to provide Add-On Data Link Control (ADLC™).

The ADLC™ concept was pioneered by MICOM SYSTEMS, INC. with a range of products which provide add-on protocol to minicomputer-based 'dumb terminal' configurations without requiring any changes to existing hardware and software.

THE ERROR CONTROLLER

The most basic element of the ADLC™ family is the Error Controller. Retransmission-on-error is particularly required at higher data transmission speeds. Although error rates with 4800 and 9600 bps modems on leased telephone lines are often as good as 1 bit in 10^6, the telephone company will provide assurances of no better than about 1 bit in 10^5. At 4800 bps, this is equivalent to one error every 20 seconds. In reality, phone line errors occur more often as random bursts of noise, rather than very frequent single bit errors, but data transmission at 2400 bps and above without retransmission-on-error is risky at best. For remote printing applications and, in particular, for graphics applications, error-free operation may be mandatory.

In addition, data transmission at 2400 bps and above requires synchronous modems, and 'dumb terminals' are asynchronous.

The Error Controller is a low-cost 'black box' designed to provide automatic retransmission-on-error as well as the mode conversion necessary to allow an asynchronous terminal to operate with synchronous modems at 2400 bps and above (the Error Controller is also sometimes referred to as an intelligent async-to-sync converter). The Error Controller is installed in pairs, one at each end of the leased telephone line (see Figure 1).

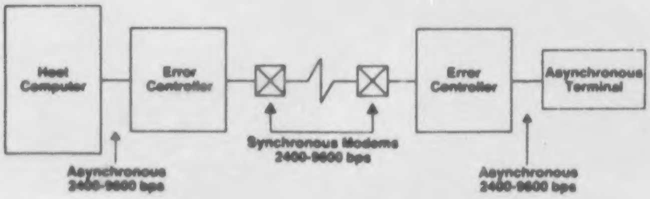
Host Computer
Error Controller
Error Controller
Asynchronous Terminal
Asynchronous 2400-9600 bps
Synchronous Modems 2400-9600 bps
Asynchronous 2400-9600 bps

Figure 1. Typical Error Controller Configuration

Special dial-up versions of the Error Controller are available which permit the full-duplex, asynchronous 'dumb terminal' to be used error-free with synchronous dial-up modems such as the Bell 201C and 208B which operate half-duplex at 2400 or 4800 bps. These dial-up versions must also serve as half-duplex-to-full-duplex protocol converters (see Figure 2).

In operation, the Error Controller receives data character-by-character from the terminal or computer port and transmits it in a block format, with block length determined by the number of characters received since the last block was transmitted. Blocks are transmitted continuously to minimize transmission delay. Each block starts with a 'Header' containing control information. This consists of the sequence number of the block, and also the sequence number of the last block received correctly in the other direction. In the event the last block was received in error, a NAK (negative acknowledgement) block will be sent. The block Header also includes a count to indicate the number of data characters in the block. Finally, a Cyclic Redundancy Check (CRC) character terminates the block. The CRC is recalculated at the receiving end to ensure that the data block was received correctly. The CRC is the 16-bit result of a polynomial calculation performed on the bits in the block. It provides only a 1 in 10^{12} probability that a CRC will check out correctly with a block in error. Thus, it reduces, to almost zero, the possibility that multiple bit errors will be 'self-cancelling' and thus avoid detection. In this respect, the CRC is a much more effective Block Check Character (BCC) than the Longitudinal Redundancy Check (LRC) character typically used in conjunction with Vertical Redundancy Check (VRC) in earlier protocols.

Any block received in error by the Error Controller is automatically retransmitted. The Error Controller employs exactly the same error control technique used in the SDLC, HDLC, or ADCCP protocols.

While a retransmission is taking place, incoming data from the terminal or computer is temporarily stored in the Error Controller's buffer memory. Despite the fact that several hundred characters of memory are provided, buffer overflow may occur, either because of excessive retransmissions or a prolonged line outage.

However, options may be provided for DEC, Hewlett-Packard, Data General, and other minicomputer users which take advantage of the fact that these minicomputer systems will suspend transmission either on receipt of a special control character (XOFF) or on the dropping of the Clear-To-Send interface control signal. Transmission will resume when the system receives the XON control character from the Error Controller or when it senses the raising of Clear-To-Send.

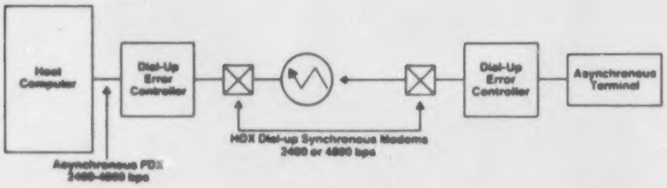

Figure 2. Typical Dial-Up Error Controller Configuration

THE DATA CONCENTRATOR

The second product in the ADLC^{TM} family is the Data Concentrator. The Data Concentrator uses statistical multiplexing techniques to allow several 'dumb terminals' to share a single telephone line, with one concentrator unit installed at each end of the line (see Figure 3). The device operates extremely efficiently with interactive CRT terminals, since it allocates the shared telephone line to each terminal dynamically, as needed, rather than on a predefined fixed basis. As a result, for example, it can allow four CRT's each operating at 2400 bps to share a single 2400 bps line. In addition, the protocol used between the concentrators incorporates the same retransmission-on-error facility provided for single terminals by the Error Controller. Thus, the Data Concentrator acts as both an error controller and cluster controller for as few as two terminals, without requiring any changes to the existing 'dumb terminal' hardware and minicomputer software. Incidentally, it also allows the asynchronous terminals to be used with high-speed synchronous modems.

In operation, the concentrator assembles characters from each active channel, building variable length data blocks for transmission down the shared high-speed line. Transmitted block length is a function of the amount of data accumulated since the last block was transmitted. All data blocks received from the high-speed line are checked for errors, and retransmissions are requested for any block received incorrectly.

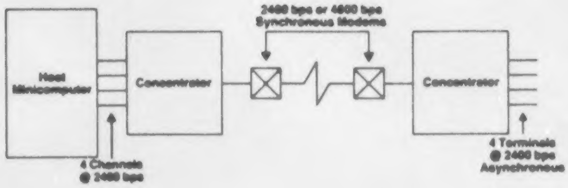

Figure 3. Typical Data Concentrator Configuration

THE MULTIDROP CONCENTRATOR

The third product in the ADLC™ family is the Multidrop Concentrator. The Multidrop Concentrator uses the same statistical multiplexing techniques as the Data Concentrator, but since it can be configured in a multipoint configuration it allows individual 'dumb terminals' and dumb terminal clusters to be multidropped at different locations to share a single multipoint telephone line.

The typical Multidrop Concentrator system links multiple regional offices with a central computer. In the example shown in Figure 4, the master Concentrator unit at the computer site is configured with 8 channels, each of which provides to the computer an apparently point-to-point transparent connection to a terminal in one of the regional offices. Regional offices are equipped with node Concentrator units, configured with 1, 2, or 4 channels.

In operation, the master Concentrator polls the remote node units at high-speed, accepting multiplexed inbound data from terminals at each site and delivering multiplexed outbound data addressed to individual terminals at each site. The multipoint data link operates synchronously at speeds to 9600 bps, but speeds of 2400 or 4800 bps are most typical. The individual 'dumb terminals' multiplexed by the node Concentrator at each site may operate at virtually any asynchronous data rate to 4800 bps.

The combination of multidrop capability, terminal cluster control and automatic retransmission-on-error, all without the need to modify existing 'dumb terminal' hardware and minicomputer software make the Multidrop Concentrator the most sophisticated of the ADLC™ products.

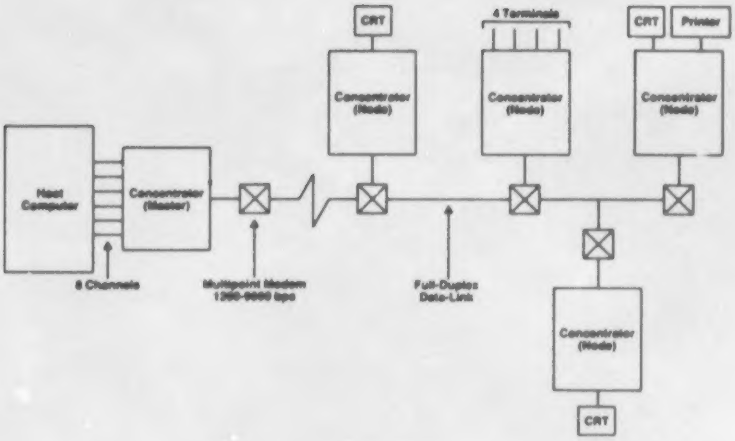
CRT
4 Terminals
CRT
Printer
Concentrator (Node)
Concentrator (Node)
Concentrator (Node)
Host Computer
Concentrator (Master)
8 Channels
Multipoint Modem 1200-9600 bps
Full-Duplex Data-Link
Concentrator (Node)
CRT

Figure 4. Typical Multidrop Concentrator Configuration

THE PORT CONCENTRATOR

The last of the ADLC™ products is the Port Concentrator. All the other ADLC™ products require no changes to existing hardware and software. They preserve the one-to-one relationship between each terminal and its associated port on the minicomputer. But in some configurations, ports may be limited. Some type of port-sharing device may be desirable.

The benefit of the true communication protocol, supported in software on the host computer, is that it allows multiple terminals to be polled using a single computer port as well as a single telephone line. But unless special software resides in the host computer, it is not possible to support multiple terminals on a single port. The purpose of the Port Concentrator is to simplify the special software required.

The Port Concentrator is used in conjunction with a Data Concentrator as shown in Figure 5.

The Port Concentrator functions as a single channel master Data Concentrator, allowing one computer port to communicate with multiple channels attached to a remote Data Concentrator using a simple asynchronous or synchronous protocol. It allows transmissions to and from the host computer to consist of simple lines of text, preceded by a terminal address.

The Port Concentrator performs more than half the work necessary to communicate directly with a remote Data Concentrator. As previously discussed, all data flow between Data Concentrators is transmitted in numbered blocks, each terminated by a 16-bit Cyclic Redundancy Check character. The Port Concentrator assumes full responsibility for the complex task of error control and only transfers error-free data blocks to the host computer. In addition, data buffering requirements caused by backup of data owing to retransmissions or temporary line outages on the link to the remote Data Concentrator are handled automatically by the Port Concentrator.

The Port Concentrator also assumes responsibility for synchronization with the remote Data Concentrator. This is necessary even when there is no data activity in order to ensure rapid response and minimum delay whenever there is data to transmit. This need for constant synchronization might otherwise impose a significant burden on the host computer. The Port Concentrator assumes all of this burden.

As a device to economize on computer ports, the Port Concentrator has only one disadvantage: unlike other ADLC™ products, it does require special software support. This is unavoidable, however, if all terminals sharing the port need to be on-line at all times.

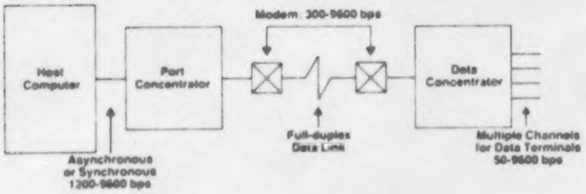
Modem: 300-9600 bps
Host Computer
Port Concentrator
Data Concentrator
Asynchronous or Synchronous 1200-9600 bps
Full-duplex Data Link
Multiple Channels for Data Terminals 50-9600 bps

Figure 5. Typical Port Concentrator Configuration

Developing a Performance Analysis for Flow Control with Window Mechanism

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Abstruct

A performance analysis of flow control with a window mechanism has been proposed. This analysis applies the approximate analytical method based on the loss-type queueing system model corresponding to the bloking-type system. Approximate analytical expressions are derived for performance measures such as throughput, average waiting time and average system size. Our analysis is applicable to the system design of flow control in computer networks.

1. INTRODUCTION

Although flow control techniques in computer networks have been studied since the ARPA network was constructed(1), it has been indicated that flow control is still one of the most important problems at present among the remaining technical promlems in network design(2). Moreover, the concept of flow control has not been universally defined. In the literature, flow control is recognized as the problem of allocating network resources to demands placed upon these resources by the user population. Enormous effort to resolve the flow control problems has been made and various kinds of techniques and concepts have been proposed. For example, there is the end(IMP)-to-end(IMP) control implemented in the ARPA network(3), the end(HOST)-to-end (HOST) control using the window mechanism(4), the isarithmic technique with a limit to the total number of packets in the network(5) and the two level flow control scheme(6). Recently, dynamic flow control scheme supported by the learning function(7) and the stochastic token limit(8) have been reported.

Flow control with a window mechanism, however, which is considered a prototype control scheme and recommended as a future technique in X. 25, has not been analyzed in general. The objective of this paper is to clarify the relationship between the window mechanism and flow control. The window mechanism is closely related to not only flow control but also packet sequencing. Therefore, we maintain the following points: 1) The window size may be determined as the parameter associated with the numbering strategy; and 2) In order to control the traffic, it is important to obtain optimum performance for the given window size.

In our analysis, the window mechanism is modelled as a blocking-type queueing system. In order to obtain the steady state probability of the system as an explicit function, it is replaced with a loss type queueing system which is shown to be equivalent to the blocking system. It is shown that this convenient replacement is powerful in the analysis of various characteristics of the window mechanism and in representing a good approximation to the blocking system. The results of the analysis and the simulation evaluate the effects and performance measures of flow control with a window mechanism.

Finally, a new control scheme which provides dynamic operation based on the previous analysis is suggested.

2. MODEL AND ASSUMPTIONS

2.1 MODELS OF FLOW CONTROL MECHANISMS

The structure of a computer network is illustrated in Figure 1. A HOST contains the packet assembly and disassembly facility(PAD), which is responsible for communication between a sending-receiving PAD pair. The structure of the PAD is modelled as in Figure 2, which can be specified more elaborately by referring to the traffic controller in (9), because the analysis descrived below applies more generally. In the sendind PAD, after the transmitter accepts messages from the user(process), it divides each message into fragments as packets. This transmitter then sends out packets into both the subnet and the retransmitter for copies of packets. The retransmitter holds a copy of each

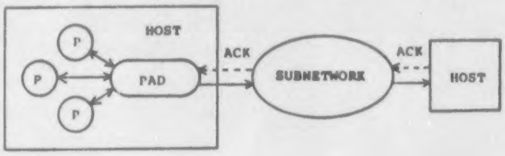


Figure 1. Structure of a computer network.

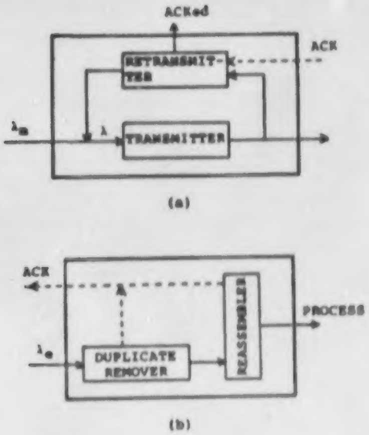
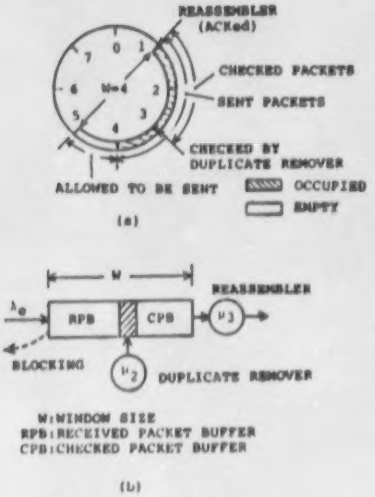
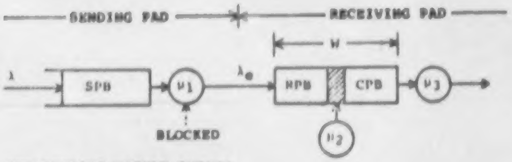


Figure 2. Structure of sending(a) and receiving(b) PAD's.



W:WINDOW SIZE
RPB:RECEIVED PACKET BUFFER
CPB:CHECKED PACKET BUFFER

Figure 3. Window mechanism(a) and the model of receiving PAD(b).



SPB:SENDING PACKET BUFFER

Figure 4. The analytical queueing model for the window mechanism.

packet. If an ACK for this packet is received within τ seconds(time out period), the copy of the packet is discarded. If, however, the ACK is not received within τ seconds, then a copy of the packet is retransmitted through the transmitter. Each packet has one sequence number(to be monotonic increasing or decreasing). The number is referred to at the receiving PAD when packets are reassembled into messages. The receiving PAD accepts each packet from the subnet, and checks the sequence number. Packets with correct sequence numbers are available for the message to the user. When a correct packet is reassembled, the reassembler sends an ACK to the sending PAD.

Let us consider the case where the receiving PAD selects a certain window size, and notifies it to the sending PAD. The sending PAD is not allowed to transmit more packets than the window size. The selection strategy for the window size depends on the range of sequence numbers and the buffer management at the receiving PAD. Figure 3(a) illustrates the window mechanism with modulo 8 numbering. The window size is 4 (packets). Three packets have been received already. In this condition, two packets of the three packets already received are checked by the duplicate remover and these packets are waiting to be restored to messages by reassembler. In terms of the capacity of the window, one more packet is allowed to be sent. If the window is filled by packets, the receiving PAD blocks the sending PAD until the first packet in the buffer is processed for restoration. This mechanism can be modelled as shown in Figure 3(b). The model consists of the receiving packet buffer (RPB), the checked packet buffer(CPB), and two servers associated with the reassembler and the duplicate remover. The total size of the buffer is equivalent to the window size. The sending PAD is simply represented by a M/M/1 queueing system (10), which consists of the sending packet buffer (SPB) and a server for the transmitter.

Let us consider the performance of the window mechanism. We assume that the subnet has a large capacity and no-delay, that is, instantaneous end-to-end communication capability. The influence of capacity and delay will be investigated later. Thus, Figure 4 shows the queueing model for the window mechanism in one logical link between the sending and receiving PAD's.

2.2 ASSUMTIONS

For the analysis in the next section, we will make the following assumptions: 1) The length of the packet header is so short that the packet length is equal to the message fragment length. Moreover, the message length is equal to a multiple of the packet length. Therefore, the unit of length used in this analysis is normalized with the packet length; 2) There are two modes of operation of the window mechanism. In accordance with assumption 1), we select the asynchronous response mode. The receiving PAD will generate an ACK as soo as a packet has been restored correctly; 3) Poisson arrival of message fragments for the user and packets from the retransmitter. The total mean arrival rate at the transmitter is denoted as λ; 4) Exponential distribution service is assumed for the transmitter, the duplicate remover and the reassembler, with means $1/\mu_1$, $1/\mu_2$ and $1/\mu_3$, respectively; 5) No arrival out of sequence; and 6) Negligible transmission error.

3. ANALYSIS

Let us start by obtaining the steady state probability for the queueing model shown in Figure 4. In general, however, it is dificult to find the steady state probability in such a complicated blocking system. In order to obtain it, numerous numerical calculations would be required. In the evaluation or design of the network, it is convenient for the steady state probability to be represented by a simple explicit function. Thus, we will introduce a loss-type queueing model with a virtual buffer, shown in Figure 5, instead of the blocking model in Figure 4. The reason why the blocking-type queueing model is replaced by the loss-type queueing model is explained in the appendix. Note that the replacement is allowed for heavy traffic in the sending PAD only. In Figure 5, the concept of a virtual buffer(VB) is introduced, the size being K(=1 or 2).

We now investigate the case where the size of the virtual buffer is one(K=1). Since arrival of packets at the receiving PAD is Poissonian, the state diagram of the receiving PAD is denoted by solid and dotted circles(○ and ◌) in Figure 6. The states denoted by solid circles are related to the size of the buffer W and the server rate μ_3. The states denoted by dotted circles are caused by an added virtual buffer. If we find a general solution to the equilibrium equations of the system, we get the blocking probability and the throughput of the system in Figure 4. However, in this case, it is also difficult to solve the equations so we have used the following technique. Firstly, in Figure 6, we ignore the states(m,n) denoted by dotted circles except for the state(W+1,0), and observe the states enclosed by the solid triangle. Thus, we can obtain the equilibrium equations and the steady state probability, as shown later. Moreover, let us assume that we can derive the maximum throughput Th_1 at K=1. The prefixed word maximum is added to indecate throughput under heavy traffic assumptions. This Th_1 is less than the intrinsic maximum throughput Th of the system shown in Figure 4 because we ignored some states in Figure 6 in order to approximate the steady state probability. However, for $\rho_2=\lambda/\mu_2 << 1$, $\rho_3=\lambda/\mu_3 << 1$ and $\rho_2=\rho_3$, Th_1 is a suitable approximation to Th. With $\rho_2>1$, $\rho_3>1$ and $\rho_2=\rho_3$, such a method is not reasonable because of the ignored states. So we add one more waiting room in the virtual buffer, namely K=2, and examine the loss-type system again. The range of the diagram is extended to include double solid circles(◎). In order to obtain the steady state probability, the states(m,n) (m, n>1, m+n=W+3) are also ignored in this case. We consider the states enclosed by the dotted triangle. Assuming the maximum throughput Th_2 is at K=2, we note that Th_2 is greater than Th for any ρ_2 and ρ_3 because all the states of the system with K=1 are involved in the solid triangle. Nevertheless, with $\rho_2>1$, $\rho_3>1$ and $\rho_2=\rho_3$, Th_2 is regarded as a reasonable approximation to Th.

From the above analysis, it is concluded that Th is related to Th_1 and Th_2 as follows:

$$Th_1 < Th < Th_2 \qquad (1)$$

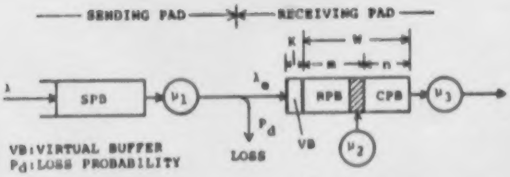


Figure 5. The approximate loss-type model with virtual buffer.

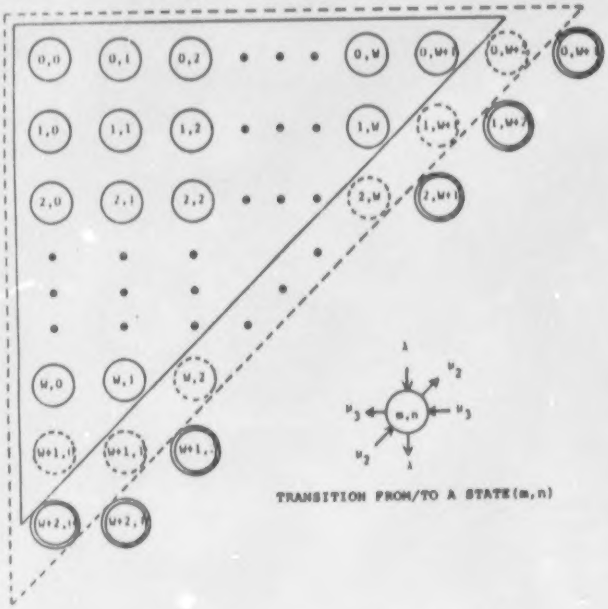


Figure 6. State transition diagram.

We then derive the equilibrium equations as shown below:

$$\left.\begin{aligned}
&\lambda p(0,0)=\mu_2 p(0,1)\\
&\mu_3 p(0,W+K)=\mu_2 p(1,W+K-1)\\
&\mu_2 p(W+K,0)=\lambda p(W+K-1,0)\\
&(\lambda+\mu_3)p(0,n)=\mu_3 p(0,n+1)+\mu_2 p(1,n-1)\\
&\qquad\qquad (1\le n\le W+K-1)\\
&(\lambda+\mu_2)p(m,0)=\mu_3 p(m,1)+\lambda p(m-1,0)\\
&\qquad\qquad (1\le m\le W+K-1)\\
&(\lambda+\mu_2+\mu_3)p(m,n)=\mu_3 p(m,n+1)+\mu_2 p(m+1,n-1)\\
&\qquad\qquad\qquad +\lambda p(m-1,n)\\
&\qquad\qquad (m\ge 1,\ n\ge 1,\ m+n\le W+K-1)\\
&(\mu_2+\mu_3)p(m,n)=\mu_2 p(m+1,n-1)+\lambda p(m-1,n)\\
&\qquad\qquad (m\ge 1,\ n\ge 1,\ m+n=W+K)
\end{aligned}\right\}\ (2)$$

We solve these and then obtain the steady state probability p(m,n) as

$$p(m,n)= \rho_2^m \rho_3^n \, p(0,0) \qquad (3)$$

where $\rho_2=\lambda/\mu_2$, $\rho_3=\lambda/\mu_3$ and $p(0,0)$ is given by

$$p(0,0)=(1-\rho_2)(1-\rho_3)(\rho_2^{W+K+1}-\rho_3^{W+K+1})/[(\rho_2-\rho_3) - (\rho_2^{W+K+2}-\rho_3^{W+K+2})+\rho_2\rho_3(\rho_2^{W+K+1}-\rho_3^{W+K+1})]$$

$$(\rho_2\neq\rho_3,\ \rho_2\neq1,\ \rho_3\neq1)$$

We can obtain expressions for performance measures as follows:
1) The average system sizes L_m of the RPB and L_n of the CPB are

$$L_m=\sum_{m=1}^{W+K}\ \sum_{n=0}^{W+K-m} mp(m,n) \qquad (4)$$

and

$$L_n=\sum_{n=1}^{W+K}\ \sum_{m=0}^{W+K-n} np(m,n) \qquad (5)$$

respectively, where K=1 or 2, which applies correspondingly to the following. Obviously, the average system size L of the receiving PAD is

$$L=L_m+L_n \qquad (6)$$

2) The loss probability P_d is derived from

$$P_d=\sum_{i=0}^{W+K} p(i,W+K-i) \qquad (7)$$

P_d is expected to be approximate blocking probability of the model in Figure 4(see appendix).
3) The throughput Th_i $(i=K)$ is given by

$$Th_i=\mu_3\Big(1-\sum_{m=0}^{W+K} p(m,0)\Big) \qquad (8)$$

Note that Th is equivalent to the average arrival rate λ_e(Poisson) from the sending PAD to the receiving PAD.

$$\lambda_e=\bar{\lambda}(1-P_d) \qquad (9)$$

4) The average waiting time W_t is obtained as

$$W_t=L/\lambda_e \qquad (10)$$

by Little's law.

After careful consideation, if the replacement technique gives good approximations to the blocking system(which will be verified in the next section), we can discuss the important properties of the window mechanism as follows: 1) The window mechanism operates to keep the maximum throughput given by expression (1); and 2) It restrains the sending PAD from transmitting wasteful packes into the subnet. Note that the loss probability in (7) may approximate the blocking probability.

4. NUMERICAL RESULTS

In this section, we firstly present numerical examples for our approximate analytical method, and verify them by simulation experiments. Secondly, we consider the replacement method when the virtual buffer can be either available or unavailable, under light traffic conditions. Finally, we show a scheme for approaching dynamic flow control.

To investigate the relation indicated in equation (1), the maximum throughputs Th, Th_1 and Th_2 are shown in Figure 7, in which Th is simulated using the model in Figure 4, and Th_1 and Th_2 derived from the loss-type system in Figure 5. From the curves of Th, Th_1 and Th_2, we can observe that the relation given in equation (1) holds because the value of Th is situated between Th_1 and Th_2.

Let us investigate other performance measures, the average system size and the average waiting time. As described below, these performance measures are estimated by using the loss-type system instead of the blocking-type system. Both performance measures for the blocking system are approximated by equations (6) and (10) for the loss-type system. Figure 8 shows the average system size. In this figure, the size of the buffer W is 5 and the size of the virtual buffer K is 2. The point denoted by '•' means the values simulated by using the blocking-type queueing system model in Figure 4. The curves drawn with solid lines are calculated from equation (6), which is derived using the loss-type queueing system model in Figure 5. Figure 9 shows the average waiting time. Similarly, we can observe the comparison of the simulated results using Figure 4 and the calculated results from equation (10). Consequently, from the above results, we conclude that the approximate analytical method used in the loss-type queueing system model gives us worthwhile results for the analysis of the complicated blocking system.

We now may discuss the properties of the performance measures in the above figures. The maximum throughput depends on the ratio of service rates(a_2 and a_3) rather than the buffer size. Therefore, it is not necessary for the window size to be made wide. The average system size is approximated well in the case where the virtual buffer size K equals 2. So, when we use the approximate analytical method, the loss-type system model with K=2 is suitable for calculating performance measures. In Figure 9, similar properties to those described above are obtained for the average waiting time. The results of this discussion converge in that the window mechanism provides fixed performance measures, although the behavior of the inner structure is complicated and changeable in terms of blocking.

We have studied the window mechanism for heavy traffic in the sending PAD so far. We are also interested in light traffic in the sending PAD. Figure 9 illustrates the performance measures in light traffic. We have made the traffic density $\rho_1=\lambda/\mu_1$ the abscissa in order to show the measures. Though our approximate analytical method is not always reasonable in this range of ρ_1, simulated results and calculated results agree over a wide range of ρ_1, which appears to satisfy our design analysis. Note that the previous case of heavy traffic in the sending PAD corresponds to that of $\rho_1=1.0$ in Figure 10. In this figure, we especially notice the "power"(2) of flow control. This power is useful in dynamic flow control utilising

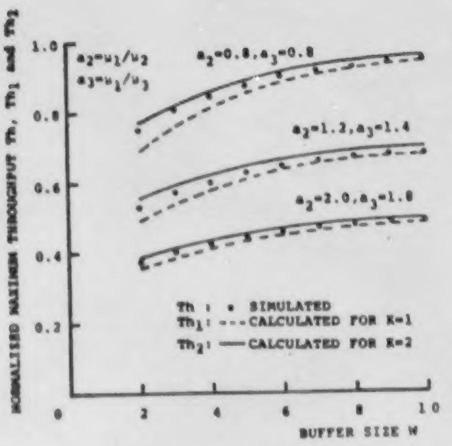


Figure 7. Normalized maximum throughput vs. buffer size W.

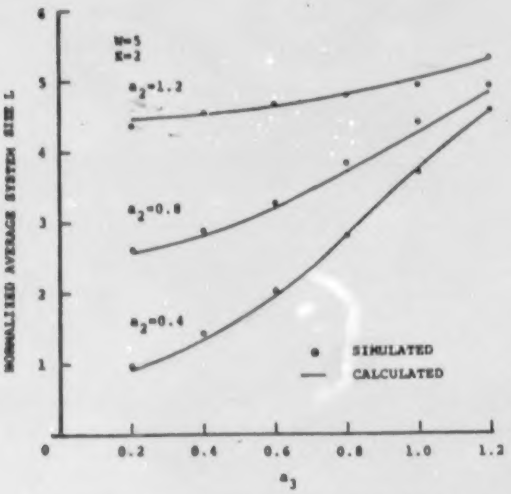


Figure 8. Normalized average system size vs. a_3.

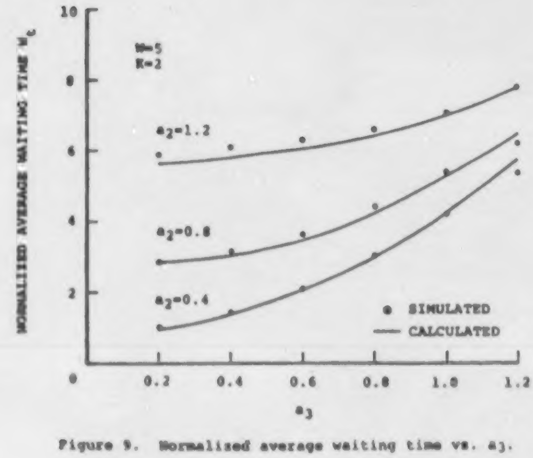


Figure 9. Normalized average waiting time vs. a_3.

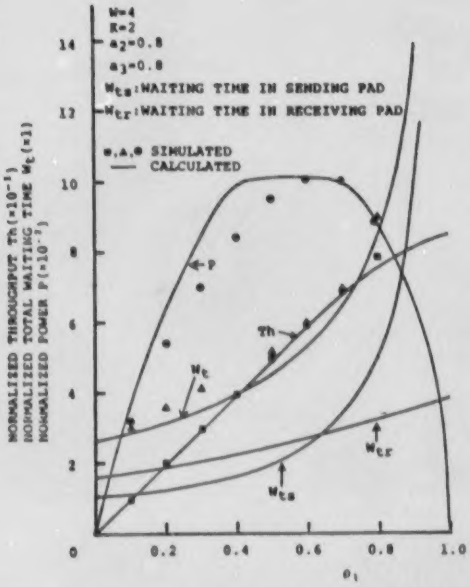


Figure 10. Normalized throughput, total waiting time and power vs. ρ_1.

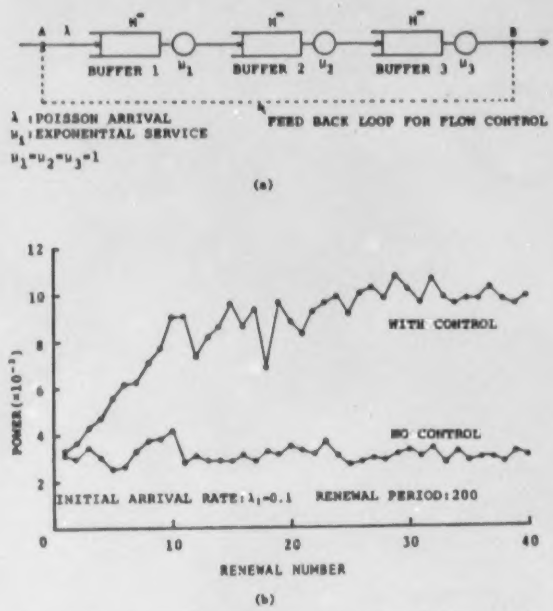


Figure 11. Structure of controlled link(a) and an example of dynamic flow control(b).

learning, as shown in Figure 11. In general, we have to recognize that a level of flow control is required to realize reasonable flow in the protocols for data communication between the sending PAD and the receiving PAD.

5. CONCLUSIONS

In order to study the performance of the window mechanism with the assumption of heavy traffic, we have attempted to model it by a blocking-type queueing system. We propose that a loss-type queueing system with virtual buffer can replace the blocking system, in order to obtain the steady state probability in the form of an explicit function. The results of the analysis were verified by simulation experiments. Some important properties of the window mechanism are as follows:

1) The window mechanism operates to keep a maximum throughput;
2) It restrains the sending PAD from transmitting wasteful packets into the subnet;
3) It has the property of a stationary congiguration in the flow control, and
4) It does not require a wide 'aperture'.

Moreover, we have examined the performance under light traffic, and have shown that the model is suitable for a wide range of traffic conditions.

APPENDIX

Let us consider the blocking-type queueing model M/M/1→M/1(W) shown in Figure A1. For the condition that there are always one or more packets in the buffer of system-1, that is heavy traffic, its compound service rate μ^* is given by(11)

$$\mu^*/\mu_1=\frac{1-a^{W+2}}{1-a^{W+3}} \qquad (a=\mu_1/\mu_2\neq 1) \qquad \text{(A1)}$$

Note that the maximum throughput of this system is defined when $\lambda=\mu^*$,

$$Th=\frac{1-a^{W+2}}{1-a^{W+3}}\mu_1 \qquad \text{(A1)'}$$

The blocking probability P_d that system-1 is blocked by system-2 is given as follows:

$$P_b=\frac{1-a}{1-a^{W+3}}a^{W+2} \qquad \text{(A2)}$$

In order to understand meaning of equations (A1)' and (A2), let us investigate the loss-type queueing model M/M/1→M/1(W) shown in Figure A2. The loss probability P_d of the system is given by

$$P_d=\frac{1-\rho}{1-\rho^{W+2}}\rho^{W+1} \qquad (\rho=\lambda/\mu_2) \qquad \text{(A3)}$$

and the arrival rate λ_e from the system-1' to the system-2' is obtained as $\lambda(1-P_d)$. Therefore, the throughput in heavy traffic is given by

$$Th=\frac{1-a^{W+1}}{1-a^{W+2}}\mu_1 \qquad \text{(A4)}$$

by using $a=\mu_1/\mu_2$ instead of $\rho=\lambda/\mu_2$.

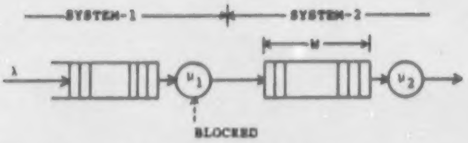


Figure A1. Blocking-type queueing model M/M/1→M/1(W).

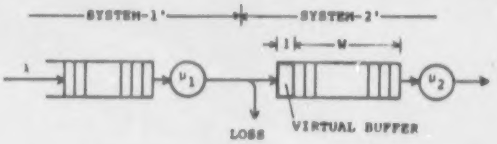


Figure A2. Equivalent loss-type queueing model to Figure A1 in terms of throughput.

If one more buffer(virtual buffer), denoted by the bold line, is assumed to be added to the buffer in system-2', equation (A4) must be rewritten as follows:

$$Th=\frac{1-a^{W+2}}{1-a^{W+3}}\mu_1 \qquad \text{(A4)'}$$

The loss probability in (A3) is also rewritten in the form

$$P_d=\frac{1-a}{1-a^{W+3}}a^{W+2} \qquad \text{(A3)'}$$

Because the form of (A1)' is the same as that of (A4)', the system shown in Figure A1 is equivalent to the loss-type system with virtual buffer in Figure A2 in terms of maximum throughput. Thus, it is concluded for heavy traffic that the blocking system in Figure A1 can be replaced by the loss-type system with virtual buffer in Figure A2. Moreover, the blocking probability is equal to the loss probability because equation (A2) is identical to (A3)'.

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A Petri Net Approach to Compute the Terminal Reliability of a Communication Network

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Abstract

A Petri net approach to compute the terminal reliability of computer network is proposed. The technique is simple and requires less computational efforts in the determination of simple paths. This is because, only vector additions are needed. The disjoint terms are obtained by giving a Petri net interpretation of a term in Boolean function.

1. INTRODUCTION

Considerable interest has been shown in determining the terminal reliability of communication networks (1)-(5) by using Boolean Algebra techniques. An alternative procedure exploiting the reachability concept of Petri net (PN) is proposed here. In the proposed technique, the communication network is represented by probablistic oriented graphs with weighted arcs and unweighted nodes, the nodes assigned to be reliable stations and the arcs represent the unreliable connections having a weight equal to its probability of existence. Further it is assumed that there is no co-relation between failures of different links and reliabilities are time invariants.Graphs having parallel arcs are excluded and assumed to be combined into one arc.

In order to find the terminal reliability of a probablistic graph, a Boolean function f (sum-of-product form) is constructed such that each term of f corresponds to one simple path. Since terms of f are not disjoint, it is not possible to replace each term by corresponding term of probabilities. Hence disjoint terms of f are obtained.

In the proposed technique first all the simple paths are determined by using the state equation representation of PN (6). It is more promising than the existing a algorithms, because, matrix multiplications are not involved. Only vector additions are needed. Then for finding the disjoint terms in f, the firing rules of PN are used. The proposed technique gives more near optimal solutions as compared to the other methods.

2. APPLICATION OF PETRI NET TO PROBABILISTIC GRAPH

A probabilistic graph consists of unweighted nodes and weighted arcs. The nodes represent reliable stations and the arcs represent unreliable connections having weight equal to its probability of existence. The arcs are in general oriented. However, for some arcs no orientation is given. For such an arc the probability of existence is same in both the directions.

A probability graph can be drawn where the probability of existence P_{ij} of arc (i,j) is given by defining a stochastic variable x_{ij} having 0,1 as definition domain, and stochastic distribution of x_{ij} as:

$$P(x_{ij} = 0) = 1 - P_{ij} = q_{ij},$$

$$P(x_{ij} = 1) = P_{ij}$$

In order to find the terminal reliability, first all the simple paths between terminal nodes are obtained as terms in Boolean sum-of-products function (SOP) f. Secondly the disjoint terms are obtained and the desired Boolean function f is determined. The terminal reliability P is then straight forwardly computed by means of the following correspondence.

x_{ij} ———— P_{ij},

$\bar{x}_{ij}$ ———— q_{ij}

Boolean sum ———— Arithmatic sum

Boolean product ———— Arithmatic product

2.1 DETERMINATION OF ALL THE SIMPLE PATHS BETWEEN THE TERMINAL NODES OF G.

A probabilistic graph G can be represented by Petri net by replacing nodes and edges by places and transitions, respectively. The transitions are assumed to fire in the direction of arc. The transitions representing undirected arcs can fire in both the directions. To find all simple paths from a terminal r to a terminal k it is sufficient to find which of the transitions would fire in order that a marking (token distribution) which has the only token at place k is reachable from a marking which has the only token at place r.

This is achieved by using the following state equation (6)

$$A^T\Sigma = \Delta M \qquad 1$$

where, A is the transition-to-place incidence matrix of PN, ΔM is the change in marking and Σ is the firing count vector.

In our case Eq.1 reduces to

$$A_1\Sigma = \Delta M \qquad 2$$

where, $A_1 = \left[a_{ij}\right]_{N\times M}$

and

a_{ij} = -1, if jth arc is going away from ith node,
= 1, if jth arc is coming towards ith node,
= ±1, if jth arc is not oriented but is incident at ith node,
= 0, otherwise

$\Delta M = \left[m_i\right]_{N\times 1}$ is a column vector where elements m_i are given by

m_i = -1 for i = r
= 1 for i = k
= 0, otherwise.

and $\Sigma = \left[e_j\right]_{M\times 1}$ is a column vector whose element e_j is 0 when the jth arc is not included in the simple path. As the paths are simple e_j can atmost be 1. Eq.2 contains N-1 independent equations in M unknowns.

Each feasible solution of Eq.2 for Σ will correspond to one simple path.

2.2 SOLUTION

A path of length L in G is a non-empty sequence of L edges. The path is simple if all edges are distinct. Thus, the solutions of Eq.2 can be obtained by column operations of A_1. Any L column vectors of A_1 can be added and if the addition equals ΔM, then a simple path of length L is given by the branches whose indices correspond to these L columns. Addition rules are (±1) + (±1) = 0, -1 ± 1 = 0, 1 ± 1 = 0. All such L combinations of columns will give all possible simple paths of length L. The number of iterations atmost will be equal to

$$\sum_{k=1}^{N-1}\binom{M}{k}$$

because the maximum number of branches in a simple path will be N-1. However, these iterations can be reduced by using properties of A_1 matrix. There may be certain nodes to which are connected only outgoing or incoming branches i.e. some rows of A_1 will not have any 1 (or -1). Two or more columns which contain -1's and 0's (or 1's and 0's) for any row can not be added because the addition can never be equal to ΔM. Such sets of columns can be identified from A_1. Hence only those L(L≥ 2) columns are considered out of which any two column do not belong to the set as obtained above.

Based upon the above discussion, following are the steps to find all simple paths between two specified nodes.

Step 1 - Find A_1 and ΔM as discussed above

Step 2 - From A_1 find all the sets S_i for $1 \leq i \leq N$ of columns corresponding to each row which contains -1's and 0's (or 1' and 0's).

Step 3 - Compare all the columns of A_1 with ΔM. If any column equals ΔM, the branch with index which corresponds to the particular column is the path of length 1.

Step 4 - Put L = 2. If it is not possible to select any L coloumn of A_1 such that no two columns of L belong to any one set obtained in Step 2, Go to Step 8.

Step 5 - Add L columns. If the addition equals ΔM, the indices corresponding to these L columns are attached to the branches to give simple path of length L.

Step 6 - Repeat Step 5 for all possible L combinations.

Step 7 - Make L = L+1 till L = M.

Step 8 - Stop.

2.3 EXAMPLE

For the graph G of Fig.1 (1) all the simple paths between terminals 1 and 4 are obtained as follows

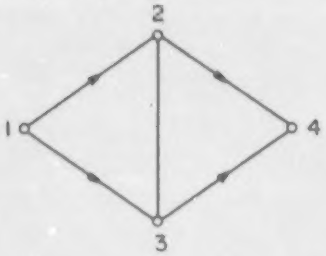

Fig. 1

Step 1 -

$$A_1 = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{ccccc} x_{12} & x_{13} & x_{23} & x_{24} & x_{34} \end{array} \\ \left[\begin{array}{ccccc} -1 & -1 & 0 & 0 & 0 \\ 1 & 0 & \pm 1 & -1 & 0 \\ 0 & 1 & \pm 1 & 0 & -1 \\ 0 & 0 & 0 & 1 & 1 \end{array}\right] \end{array}$$

and

$$M = \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \end{array} \left[\begin{array}{c} -1 \\ 0 \\ 0 \\ 1 \end{array}\right]$$

Step 2 -

$$S_1 = (x_{12}, x_{13});\ S_4 = (x_{24}, x_{34})$$

Step 3 - It is found that none of the columns equals ΔM, hence there is no path of length 1.

Step 4,5,6 - L = 2, It is found that addition of columns corresponding to x_{12} and x_{24} equals ΔM giving thereby a path of length 2 as $(x_{12}x_{24})$. Other simple path of length 2 is $x_{13}x_{34}$.

Step 7 - Similarly simple paths of length 3 are $(x_{12}x_{23}x_{34})$ and $(x_{13}x_{23}x_{34})$. There is no other simple path.

Hence, the Boolean function (SOP form) f is given by

$$f = x_{12}x_{24} + x_{13}x_{34} + x_{12}x_{23}x_{34} + x_{13}x_{23}x_{24}.$$

2.4 DETERMINATION OF DISJOINT TERMS OF f.

Each term of f can be represented by a transition whose inputs are the logic variables of that term. The number of transitions will be equal to the number of terms in f. For two terms t_i and t_j, the PN representation of f is shown on the right hand side of Fig.2.

The variables $m (m \geq 1)$ are common to both the transitions. The variables x_i is the input only to t_i and k variables (not including x_i) are input only to t_j. Obviously, t_i and t_j are not disjoint because both the transitions can fire simultaneously. It can be seen easily that as far as the availability of output is concerned, left hand side and right hand side of Fig.2 are equivalent. But t_i and t'_j cannot fire simultaneously making the transitions disjoint

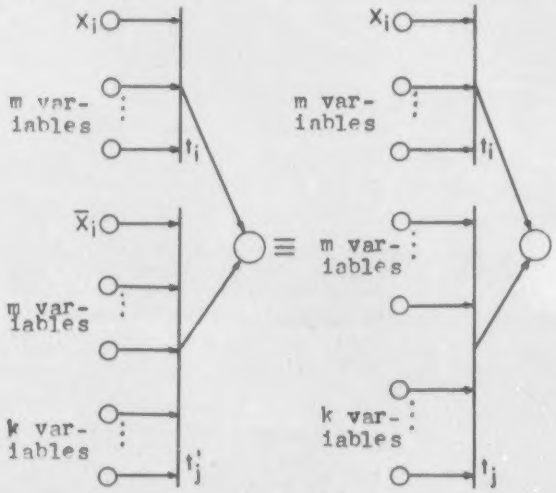

Fig. 2

It may be noted that one of the transitions corresponding to a term in function f is to be considered as a basis to find the disjoint transitions. In order to reduce the number of computations the transition in which input contains minimum number of variables is selected as the basis. Let such a transition be t_i and one of the inputs to it be x_j. Any transition which has one of the inputs $\bar{x}_j$ will be disjoint with t_i. Consider another transition t_k ($k \neq i$). Three possibilities can exist for the inputs to t_k,

i) variable is present as x_j
ii) variable is present as $\bar{x}_j$, and
iii) variable x_j is absent.

For case (i) obviously t_k is not disjoint to t_i. However, because the simple paths are different, there will be atleast one variable which is input to t_i, and not to t_k and t_k is made disjoint to t_i by adding complement input of that particular variable to t_k.

Since the function f contains only uncomplemented terms, case (ii) will not be present in the beginning but in subsequent computations this case may be present. In this case, t_k is disjoint to t_i.

For case (iii) an input $\bar{x}_j$ is aided to t_k.

Hence, for every input variable to transition t_i all the transitions disjoint to t_i are obtained. Ignoring t_i, consider the transitions obtained. Obviously they may not be disjoint to each other. The above procedure is repeated till all the transitions disjoint to each other are obtained.

A procedure based on above discussion to obtain all disjoint terms from simple paths is as under-

Step 1 - Represent all simple paths in tabular form where a row corresponds to a path and a column to a variable. If a variable j is present in a path i, then the entry for (i,j) in table is 1. Otherwise the entry is *(where * denotes the absence of the variables in the path).

Step 2 - Select a row in the table for which maximum number of *'s appear. Call it a basis row. If any row does not contain a *, then it does not take part in further computation but corresponds to one of the terms in disjoint function.

Step 3 - For the basis row, select a column j of non * entry. Determine the complement of the entry, say C_j. Obtain a new table whose entries in columns other than jth column for the remaining rows are same as in the table obtained in Step 1. The entry for jth column and ith row is determined by multiplying the entry (i,j) of the preceding table by C_j according to following rule,

0.0 = 0
1.1 = 1
1.* = 1
0.* = 0

However, for any row i and column j, if the multiplicant is complement of C_j, the ith row is not entered in the new table.

Repeat the step 3 for all non entries of the basis row and add rows to the new table. Note that the new table does not contain the basis row.

Step 4 - Go to step 2 and repeat till there is only one row in the new table.

Step 5 - Find conjunctive functions for each basis row (including that of final table) and the rows without any * by putting the uncomplemented variables for '1' in corresponding columns and complemented variables for '0' in corresponding columns. The function of all disjoint terms is, thus the disjunction of all conjunctive functions.

The above procedure is illustrated with the help of example of Fig.1.

Step 1 - Table 1 is obtained as

Variables		x_{12}	x_{24}	x_{13}	x_{34}	x_{23}	
rows	1	1	1	*	*	*	←Basis row
	2	1	*	*	1	1	
	3	*	*	1	1	*	
	4	*	1	1	*	1	

Table 1

Step 2,3 - Arbitrarily row 1 is selected as basis row (instead of row 3) and $C_{12} = 0$, $C_{24} = 0$.

Considering $C_{12} = 0$ first and then $C_{24} = 0$, table 2 is obtained as

Variables	x_{12}	x_{24}	x_{13}	x_{34}	x_{23}	
rows	0	*	1	1	*	
	0	1	1	*	1	
	1	0	*	1	1	
	*	0	1	1	*	←Basis row

Table 2

Step 4,5 - The table 2 does not contain only one row and hence repeating step 2, the row 4 of table 2 is the basis row and $C_4=1$, $C_{13}=0$, $C_{34}=1$, new table 3 is obtained

Variables	x_{12}	x_{24}	x_{13}	x_{34}	x_{23}	
rows	1	0	0	1	1	←One of the soln.
	0	1	1	1	*	
	0	1	1	*	1	←Basis row

Table 3

Proceeding in a similar way the following final table consisting of the three basis rows and the fully assigned rows gives the required solution.

Variables	x_{12}	x_{24}	x_{13}	x_{34}	x_{23}
rows	1	1	*	*	*
	*	0	1	1	*
-	1	0	0	1	1
	0	1	1	*	1
	0	1	1	1	0

Table 4

Therefore, the function f is given by

$$f = x_{12}x_{24}+\bar{x}_{24}x_{13}x_{34}+x_{12}\bar{x}_{24}\bar{x}_{13}x_{34}x_{23}$$
$$+\bar{x}_{12}x_{24}x_{13}x_{23}+\bar{x}_{12}x_{24}x_{13}x_{34}\bar{x}_{23}$$

From the correspondence of the variables with probability, the total probability P is given by

$$P = p_{12}p_{24}+q_{24}p_{13}p_{34}+p_{12}q_{24}q_{13}p_{34}p_{23}$$
$$+q_{12}p_{24}p_{13}p_{23}+q_{12}p_{24}p_{13}p_{34}q_{23}.$$

It can be seen that the result is not the same as obtained in (1). The difference is because of the selection of the basis rows. However, the solution obtained by the proposed technique will be more nearer to the optimal solution because the basis rows are selected such that minimum number of non * entries are in the row.

3. CONCLUSION

A new approach of PN has been exploited in determining the terminal reliability of a probablistic graph. The determination of simple paths is novel and is achieved by using reachability concept of PN. This is simple and easily amenable on digital computer. It requires less computational efforts because unlike other existing techniques, only vector addition of columns of a matrix is needed. The determination of disjoint terms of f is similar to that suggested (1). However, the proposed technique gives a Petri net interpretation. Further, it gives the solutions nearer to the optimal. This is because of proper selection of basis transitions.

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THE CHANGING ENVIRONMENT FOR TELECOMMUNICATIONS FACILITIES DEVELOPMENT IN THE PACIFIC

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ABSTRACT

The Pacific Ocean region presents telecommunications facilities planners with a variety of problems: geographic distance, differing levels of national economic and telecommunications development, and uneven jurisdictional coverage by and development of planning organizations. To that traditional mix of imposing problems has most recently been added a new phenomenon - rapid traffic growth.

I. The Changing Pacific Scene

In the past, facilities planners in the Pacific have been able to operate more or less without a sense of urgency. Whether because of the geographic distances involved, or the age-old trading patterns which existed, or because of the cultural diversity among Pacific peoples, the volume of transpacific communications traffic has been relatively light. By the end of 1980, about 2,440 circuits were expected to be active on INTELSAT's Pacific primary satellite, compared to more than 14,000 on three satellites in the Atlantic, and about 5,300 on the Indian Ocean's two satellites (an operational spare began service there in 1980 to supplement the Indian Ocean primary satellite).

A. Traffic Growth Takes Off

The environment for facilities planning in the Pacific has, however, begun to change in the last few years. A new element has been added--traffic growth--not the slow increases of past years, but rapid growth, especially from the mainland of the United States to almost every Pacific point. This growth is not only evident along the major U.S.-to-Pacific pathways served by COMSAT--to Australia, Hong Kong, Japan, the Republic of Korea, the Philippines, and Taiwan--but across the board.

This growth rate is exemplified by AT&T's experiences. AT&T had filed a satellite and cable circuit activation plan for the Pacific in 1978 with the FCC which was supposed to carry it through 1980. By October 1979 it had had to file a new plan for 1980 and 1981, which it in turn had to amend, in full, six months later, because of the rapid rate of traffic growth which was accelerating despite economic uncertainty. In the second, April 1980, filing, AT&T reported that actual growth in message traffic from the United States to 19 different Asian and Pacific points in 1979 had grown by an average of more than 50 percent over the year before. This was more than twice the rate of growth they had earlier predicted.(1) The circuit activation forecasts presented in that April 1980 filing predicted 65.8 percent circuit growth during 1980 with an additional 70.9 percent increase in capacity needed for 1981.(2) Both forecasts were higher than the ones presented in the October 1979 filing.(3)

Though similiar statistics are harder to come by for the international record carriers, they were, by the first half of 1980, already being granted FCC permission to acquire cable circuits which under their 1979-1980 plans filed with the FCC they had not expected to need until this year, 1981.(4)

B. Telecommunication Facilities

AT&T proposed to place much of the newly-projected growth in the amended plan it filed in April 1980 on the INTELSAT Pacific satellite, because, it stated, of the growing saturation of key cable links in the Pacific. The major transoceanic undersea cables now in service include TRANSPACs-1 and 2, COMPAC-1, and SEACOMs 1 and 2.(5) AT&T, in its April 1980 FCC filing, said, "The overall impact of the amendment of the forecast for the blanket period will be a significant increase in the level of satellite facility utilization, from 65.2 percent to 70.9 percent, in the Pacific Region by year-end 1981."(6)

AT&T attributes the rapid traffic growth in the Pacific to falling rates, and mostly, the introduction of international customer direct dialing connections between many more Pacific destinations and American cities than originally planned.(7)

As a result, COMSAT, and thus INTELSAT, have also had to revise their forecasts of satellite circuit activations and utilization upward. Fortunately, the number of nations with satellite earth stations and membership or a user relationship with INTELSAT in the Pacific has continued to grow, providing routing alternatives for traffic planners (Table 1). The INTELSAT IV which has served the Pacific since its launch in December 1974 has performed admirably. Its replacement by an INTELSAT IV-A satellite has been somewhat delayed by the launch schedule of the new INTELSAT V satellites. However, a IV-A, which has 50 percent greater capacity than the IV model, should be over the Pacific by the end of this year. And, in 1984, the Pacific should get an INTELSAT V, with its 12,000 circuit capacity and other advanced features. INTELSAT satellites continue to offer reliable and flexible service among the nations of the Pacific region.

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*The opinions expressed in this paper are those of the author and not necessarily those of the Communications Satellite Corporation.

II. The Vast Pacific

This increase in the rate of traffic growth overlays the existing environment for telecommunications development in the Pacific, which is, in many ways, very unique.

The first factor one is struck by when considering the problems of telecommunications planning in the Pacific is the vastness of the problem, not just the distances involved, but in the diversity of needs to be served, nations and actors involved, organizations to be considered, and the financial complexities of meeting the challenges created by these other factors.

The financial costs involved in bridging the huge geographic distances were clearly highlighted last May when the Australian government announced plans for the new ANZCAN cable system, which will link Australia and New Zealand with Fiji, Hawaii, and Canada by 1984. The Australian government said that it estimated that the whole project would cost about A$350 million, of which the Overseas Telecommunications Commission (Australia) alone would contribute up to $A200 million. The list of other governments and communications authorities involved in this project, which will replace the COMPAC-1 cable, also served to illustrate the diversity in economic and telecommunications development and interests in the Pacific. From the Pacific region, Australia, New Zealand, the Philippines, Fiji, and Papua New Guinea are to be involved in the finance and construction of the system. In addition, Britain, West Germany, and France are extra-regional participants in this massive undertaking.(8)

A. Economic and Telecommunications Development Diversity

A look at Table 2 illustrates the problems of planning telecommunications facilities in the Pacific. The wide diversity in GNP per capita among nations in the Pacific, which is one indicator of the state of economic development of a country, the great differences in domestic telephone density, and the varying volumes of international telephone traffic contributes to the complexities of providing service to the region.

For contrast, compare the Pacific region's figures with those of the Atlantic Ocean region, the other major ocean region of the world which has been bridged by both undersea cables and by satellite links. The relative uniformity in economic development, high average GNP per capita, domestic telephone density, as well as the shorter geographic distances involved, makes the job of facilities planning in the North Atlantic, in some ways, easier.

TABLE 1

PACIFIC INTELSAT EARTH STATIONS
AS OF DECEMBER 1980

Location	Type*	Service Entry Date
Am. Samoa (U.S.)	B	1979
Australia:#		
Moree	A	1968
Carnarvon	A	1969
Canada#	A	1972
Cook Islands	B	1980
P.R. China:#		
Peking	A	1973
Shanghai	A	1973
Fiji#	A	1976
Fr. Polynesia	B	1978
Guam (U.S.)	A	1969
Hong Kong	A	1969
Indonesia#	A	1969
Japan#	A	1971
R.O. Korea#	A	1970
Nauru	B	1975
New Caledonia	A	1976
New Zealand#	A	1971
Philippines#	A	1968
Saipan (U.S.)	B	1980
Singapore#	A	1974
Solomon Islands	B	1978
Taiwan	A	1969
Thailand#	A	1968
Tonga	B	1978
United States:#		
Brewster, Wash.	A	1966
Jamesburg, Cal.	A	1968
Paumalu, Hawaii	A	1968
Vanuatu	B	1979
Western Samoa	B	1980
	PLANNED	
Kiribati	B	1981
Malaysia#	A	1981
Papua N. Guinea	B	1982

*Standard A earth stations have 30-meter antennas, Standard B earth stations have 11-meter antennas.

#Parties to the INTELSAT Agreements.

Of course, the high volume of international traffic and the rate of traffic growth in the North Atlantic places pressures on facilities planners in the North Atlantic which have not been felt in the Pacific--until recently. The differences in transoceanic circuit capacity noted earlier between the North Atlantic and Pacific regions coincides with the number of major transoceanic facilities now active in the two regions. The North Atlantic has seven active transoceanic cables and three INTELSAT satellites. The Pacific has been able to accommodate its transoceanic telecommunications needs via three major cable systems and one INTELSAT satellite.

Nations active in the Pacific are a representative sample, really, of the whole world. There are OECD members, as well as members of the Non-Aligned Movement; representatives of the First, Second, Third, and Fourth Worlds; and developed, developing, and newly industrialized countries (NICs); often in relatively close proximity to each other and in constant communications. The types of political and economic/social systems to be found are just as diverse.

TABLE 2

COMPARATIVE STATISTICS: GNP PER CAPITA AND TELECOMMUNICATIONS

COUNTRY	GNP PER CAPITA (1977)	TELEPHONES 100 POP. (1977)	INTERNATIONAL TELEPHONE CALLS IN 1977 (MILLIONS)
I. Pacific Region			
Australia	$7,340	40.40	3.81
China (P.R)	390	8.49*	0.06
Fiji	1,210	5.45	.97
Indonesia	300	.25	.77
Japan	5,670	42.44**	6.28**
Korea (R.O.K.)	820	5.42	1.67
Malaysia	930	2.90	0.32
Nauru	-	21.00	0.01
New Zealand	4,380	53.31	.92
Papua N. Guinea	490	1.30	1.50
Philippines	450	1.27	1.08
Singapore	2,880	17.10	1.12
Solomon Islands	250	-	-
Taiwan	1,170	-	-
Thailand	420	0.83	0.17
Western Samoa	360	-	-
AVERAGE	$1,804	12.36	TOTAL 18.68
II. North America			
USA	$8,520	74.4	50.6
Canada	8,460	61.8	65.0
AVERAGE	$8,490	68.1	TOTAL 115.6
III. Major CEPT Countries			
Austria	$6,130	32.5	40.7
Belgium	7,590	31.5	47.6
Cyprus	1,830	13.4	6.8
Denmark	8,040	53.4	18.9
Finland	6,160	42.9	38.6
France	7,290	32.9	390.19#
Germany (F.R.)	8,160	37.4	155.5
Greece	2,810	25.0	11.9
Iceland	7,070	42.9	0.14
Ireland	2,880	16.1	34.6
Italy	3,440	27.1*	28.9*
Luxembourg	7,160	52.3	37.6
Malta	1,870	21.8	0.6
Netherlands	7,150	41.8	63.5
Norway	8,550	38.6	11.7
Portugal	1,890	12.0	13.0
Spain	3,190	26.2	28.3
Sweden	9,250	71.7	31.4
Switzerland	9,970	65.6	28.4
Turkey	1,110	2.8*	4.2*
U.K.	4,420	41.5	55.3*
Yugoslavia	1,960	7.1	3.35
AVERAGE	$5,035	33.5	TOTAL 960.99

IV. Summary by Region

	NATIONS (No.)	GNP PER CAPITA (1977)	PHONES PER 100 POP. (1977)	INT'L PHONE CALLS, 1977 (Millions)
CEPT	22	$5,035	33.5	960.99
Pacific	16	1,840	12.3	18.68
America	2	8,490	68.1	115.6

*1976.

**1978.

#Includes both domestic and international calls. Not included in total below.

Sources: World Bank, World Development Indicators, June 1979; International Telecommunication Union, Yearbook of Common Carrier Telecommunication Statistics (6th Edition) and Radiocommunication Statistics (Year 1977), (Geneva, 1977).

B. Regulatory Diversity

This same variety can be found in the philosophies various governments and telecommunications operators bring to planning issues. Americans, if they step back a moment and compare their unique regulatory regime with its equivalents in even our fellow OECD members in the Pacific, should be amazed at the difference. Teleglobe Canada, OTC(A), the New Zealand Post Office and KDD in Japan are basically the sole providers of international communications for their respective countries.

In the United States, on the other hand, our unique system has bred a diversity of private sector actors with quite different interests as far as what we want from international facilities development in the Pacific or the Atlantic. This diversity among international service carriers' interests is matched by the complexity of the regulatory and government side of international facilities planning in the United States.

C. Organizational Vacuums and Overlaps

Given the distances of all kinds which exist among the nations of the Pacific, it is not surprising that no single organization has firmly implanted itself throughout the Pacific region to coordinate international facilities development. Some have succeeded, to some extent, in coordinating subregional development and others are only lately beginning to attempt the task of uniting larger cross sections of the Pacific community.

1 The INTELSAT Connection

The International Telecommunications Satellite Organization is the most inclusive telecommunications organization in the Pacific. There are about 25 nations and territories in the Pacific which operate through the Pacific region satellite (Table 1), and are either members of the organization or non-member users. INTELSAT's Board of Governors not only has governors representing the United States, Australia, Japan, and Canada individually, but an Asia/Pacific Group (India, Malaysia, New Zealand, and Singapore), a governor jointly representing Iran/Korea/Pakistan/Turkey, and a Southeast Asia Group composed of Indonesia, the Philippines, and Thailand. Together they account for nearly 40 percent of the voting shares of the Board.

Though INTELSAT's main function is to provide satellite communications facilities for global communications, INTELSAT's broad membership and use throughout the Pacific is significant because, with a few exceptions (see Table 3), most of the operational and signatory representatives are also their nation's cable correspondents.(9)

2 The Asia Pacific Telecommunity

The Asia Pacific Telecommunity came into official existence in May 1979, although its consitution had been approved three years before in a conference of the member-nations of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). The Telecommunity's fifteen original member nations (Afghanistan, Australia, Bangladesh, Burma, the People's Republic of China, India, Japan, the Republic of Korea, Malaysia, Nauru, Nepal, Pakistan, the Philippines, Singapore, and Thailand) again demonstrate the geographic scope of the planning problems in the region. The Telecommunity's Constitution calls for it to become heavily involved in regional telecommunications planning.(10) The official intergovernmental nature of the agreement which formed the Telecommunity underscores the potential it has for becoming an important force for planning the region. But it is a young organization and only time and experience will determine whether it will fulfill its apparent promise.

3. The Pacific Telecommunications Council

The Pacific Telecommunications Council is celebrating its first birthday with this conclave. Its membership is, on the whole, quite different from that of the Telecommunity since it is not primarily intergovernmental. Users and providers of telecommunications equipment and services have joined the organization. Again, one cannot make a judgment of how successful the PTC will be in bringing together the divergent interests of its potential audience in a coherent and useful form. But one can hope. Its Pacific-wide scope and the addition of Mexico and other Latin American American representatives presents an opportunity for the creation of at least one forum in which telecommunications people of the region can exchange ideas on a broad scale.(11)

4. ASEAN

The Association of South East Asian Nations (ASEAN), on the other hand, has become a focus for telecommunications planning in that corner of the Pacific (Indonesia, Malaysia, Philippines, Singapore and Thailand). ASEAN cables are already beginning to criss-cross the South China Sea, while PALAPA satellites provide primarily domestic satellite communications capacity for some of the ASEAN nations.(12)

5. SPF/SPEC

The South Pacific Forum/South Pacific Bureau for Economic Cooperation (SPF/SPEC) has focused attention at the intergovermental level on the regional communications needs of its members: Australia, the Cook Islands, Fiji, Kiribati, Nauru, New Zealand, Niue, Papua New Guinea, the Solomon Islands, Tonga, Tuvalu, and Western Samoa. The SPEC, which acts as the permanent secretariat for the SPF, has sponsored a team of International Telecommunication Union (ITU) experts which has studied the telecommunications needs of the Southwest Pacific area. In addition, the two

TABLE 3

COMPARISON OF AT&T's PACIFIC CABLE CORRESPONDENTS AND INTELSAT EARTH STATION OPERATORS

COUNTRY	CABLE CORRESPONDENT	EARTH STATION OPERATOR
American Samoa	none	COMSAT
Australia	OTC(A)	same
P.R. China	none	Peking Adm. of Long Distance Telecommunication
Cook Islands	none	Cable and Wireless
Fiji	Fiji International Telecommunications (FINTEL)	same
Fr. Polynesia (Fr.)	none	Direction des Telecom. du Reseau International (DTRI)
Guam (U.S.)	RCA Globcom	COMSAT
Hong Kong (U.K.)	Cable & Wireless	same
Indonesia	PERUMTEL*	same
Japan	KDD	same
Rep. of Korea	none	Ministry of Communications
Malaysia	Telecommunications Department of Malaysia (TDM)	same
Nauru	none	Government of Nauru
New Caledonia (Fr.)	none	DTRI
New Zealand	New Zealand Post Office	same
Papua N. Guinea	Department of Post & Telegraph	none
Philippines	Philippines Long Distance Telephone Company (PLDT)	PHILCOMSAT
Saipan	none	COMSAT
Singapore	Telecommunication Authority of Singapore (TAS)	same
Solomon Islands	none	Cable & Wireless
Taiwan	International Telecommunication Administration (ITA)	International Telecoms. Development Corp.
Tonga	none	Cable & Wireless
Thailand	none	Coms. Authority of Thailand (CAT)
Vanuatu	none	Cable & Wireless
Western Samoa	none	W. Samoa Post Office

*Some circuits via TAT-6 to France, through French and Spanish earth stations to the INTELSAT Indian Ocean satellite, to Indonesia.

organizanizations are providing a regional advisory service for nations in the area.(13)

6. The ITU

The regional office of the ITU in Fiji is, of course, also quite active in helping the island nations of the South Pacific especially to develop their domestic and international telecommunications infrastructures.(14) The ITU has additional offices in Manila and other locations in Asia.

7. Other Arenas

In addition, of course, one cannot fail to mention two rather different arenas in which Pacific facilities planning has taken place in the past: through the U.S. international telecommunications regulatory process and in ad hoc groups of operating entities, such as the ANZCAN group, which have assembled periodically to plan cable development. The importance of the Federal Communications Commission to Pacific telecommunications planners cannot be understated. Not only is the traffic volume of the carriers regulated by the FCC large, but the geographic reach of the U.S. regulatory process is equally long. Two of the key communications nodes in the Pacific - Hawaii and Guam - are under U.S. jurisdiction and FCC regulatory control.

As for the ad hoc cable-planning groups which have, for instance, met over the last few years to plan future cable development in the Pacific, their membership and goals have often been unclear to major operating entities in the Pacific which are not both cable and satellite operators. This can lead to information gaps.

The logic of complementarity and cooperation in the development of facilities, especially in the Pacific, was brought home early last year. An Australian delegate to the IEE's International Conference on Submarine Telecommunication Systems in London was unable to attend, but delivered his paper anyway via a real-time video satellite link from Australia to Britain.(15)

III. The Challenge for the Next Decade

Telecommunications facilities providers in the Pacific will have to assess the direction and long-term trends of the traffic growth which has been exhibited in the last few years. Much like the ocean itself, traffic in the Pacific has had a tendency to take unexpected departures from the predicted. The mid-70s, for instance, saw a marked drop in international communications traffic growth in the Pacific for several reasons. We could be fooled again. The surge we see now could be the crest of wave, with another trough just beyond, or a continuing tide which will not abate shortly.

A. Major Questions

Attention must be focused on several questions. One would expect that a general downturn in the economy would lead to a slowing of the rate of telcommunications traffic growth. However, the surge in growth we have seen in the last two years came at a time when the United States was going through a fairly deep recession. How, then, are these two factors related? Further, when will the predicted trade-offs between air travel and communications begin to be manifested? One would expect that the Pacific might be the first region to begin to see such trade-offs.

B. The China Puzzle

What will be the role of the People's Republic of China in the economic, and thus, telecommunications life of the Pacific? AT&T Long Lines representatives have already floated the idea of a cable connection between the United States and the Chinese mainland, perhaps through Japan. When AT&T suggested it, the Chinese and AT&T representatives agreed that satellite links are now, and will be for some time, adequate for traffic between the U.S. and the PRC.(16) However, if trade continues to grow between the PRC and other Pacific region nations, what is now a relatively small amount of satellite communications traffic will likely grow in volume, adding an important new element into the Pacific telecommunications picture.

C. The Latin American Factor

In a similar manner, what will be the role of Mexico and the other Latin American countries in the Pacific during the 1980s? New trade ties are being forged, particularly with Japan. Though Central and South America have traditionally had their primary trade ties with Europe and North America, centuries of tradition do not necessarily translate into immutable predictions for the future.

D. Deregulation

Finally, what will be the final outcome and impact of the U.S. Congress' and the FCC's efforts to, at the same time, foster deregulation and more competition, while bringing order to facilities planning?(17) The foreign counterparts and colleagues of the U.S. international service carriers are no doubt as interested in this question as are Americans.

IV. Meeting the Demand

A. New Facilities

To meet the growing international traffic demands in the Pacific, it is not too farfetched to envision INTELSAT making the transition from a one satellite operation to a two-satellite configuration, offering diversity first through an operational spare and later through a major path satellite.

New and interesting ideas for the complementary development of cables continue to appear. Various ideas have been put forward, including a proposal made at the International Telephone and Telegraph Consultative Committee's (CCITT) World Plan Meeting in Paris last year for a fiber optic cable which would be laid between the West Coast of the continental United States to Japan via the great circle route (in other words, looping north towards Alaska) without another landfall. Operation was targeted for the late 1980s.(18) Other, conventional technology cables have been proposed.

B. Development Communications Needs

Along the way, the needs of the smallest and least developed nations of the region must not be forgotten. Many of the island nations and territories of the South Pacific already have or are planning to build INTELSAT earth stations (see Table 1). For many of the smaller nations of the region, satellites, with their unique flexibility, range and cost-insensitivity to distance, will remain the best and often only means for effective international communications. COMSAT's experiences in American Samoa have demonstrated, too, that there may be more traffic "out there" than one would expect.

The special communications needs created by economic underdevelopment in many of the nations in the region calls for cooperation between what traditionally has been two separate camps - the commercial communications carriers and development communications experimenters and users - so that the needs of the latter can be met through services offered by the former.(19)

INTELSAT has already, of course, begun moving ahead with plans for and the design of additional satellites to meet the world-wide demand for satellite capacity to meet domestic telecommunications needs

V. Conclusion

The days of wondering whether growth of international telecommunications traffic in the Pacific Region would ever take-off are gone, probably for good. People throughout the Pacific are discovering that they want to talk to each other, and this vast ocean is finally beginning to shrink and contract into part of the global telecommunication village.

It will be up to those of us who supply and use communications to figure out how best to speed that process. The only problem may be that we will be despoiling the last refuges of those seeking to escape from the world - and the telephone. Gauguin would be displeased, but the ancestors of his famous subjects probably are not.

FOOTNOTES

(1) American Telephone and Telegraph, "Amendment to AT&T's 1980-1981 Pacific Region Satellite and Cable Circuit Blanket Application," submitted to the U.S. Federal Communications Commission, Application File No. I-P-C-76, 16 April 1980, Appendix A.

(2) Ibid., Appendix B-1.

(3) American Telephone and Telegraph, "AT&T's 1980-1981 Pacific Region Satellite and Cable Circuit Blanket Application," Submitted to the U.S. Federal Communications Commission, Application File No. I-P-C-76, 1 October 1979, Appendix B-1.

(4) United States, Federal Communications Commission, "Memorandum Opinion, Order and Authorization," in the matter of RCA Global Communications, Western Union International, and ITT World Communications Acquisition and Activation of Hawaii-3/Transpac-2, OLUHO and ASEAN Cable System Circuits, I-T-C-2530-6, 6A; I-T-C-2845; I-T-C-2985, 21 May 1980.

(5) AT&T, "Amendment," Appendix C, Section 1.

(6) AT&T, "Amendment," p. 9.

(7) Ibid., p. 8.

(8) "$350-M. Pacific Ocean Cable Link Project," Weekly Newsletter, Australian Information Service, New York, 23 May 1980, p. 3.

(9) See Table 1 and Randolph H. Payne, "Telecommunications Planning in the Pacific," Pacific Telecommunications Conference Proceedings, 7-9 January 1980, Honolulu, p. 21.

(10) "Constitution of the Asia-Pacific Telecommunity," Telecommunication Journal 42(1979):672-675.

(11) "Pacific Telecommunications Council Charter," signed 9 January 1980, Honolulu.

(12) Ceferino S. Carreon, "The Asian and the Pacific Telecommunication Network," The Third World Telecommunication Forum, Proceedings, 19-21 September 1979, Geneva, pp. VI.4.1 - VI.4.7.

(13) "Satellites Over Asian and Pacific Nations Meet Growing Communications Requirements," Broadcasting Management/Engineering, February 1980.

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(15) Lewis Holmes, "Future of Submarine Communications Seen in Optical Fibers," IEE News, April 1980 (No. 52), p. 12.

(16) Richard B. Nichols, "Telecommunications Service in China," Signal, January 1980, pp. 42-44.

(17) See, for instance, "Communications Act Amendments of 1980," Congressional Record, S7015-S7033, 13 June 1980.

(18) S. Shimura, "Submarine Cables in the Asian and Pacific Area," paper presented at the CCITT World Plan Meeting, Paris, 9-18 April 1980, p. 5.

(19) Anna Casey-Stahmer, "The Era of Experimental Satellites: Where to go from Here," Journal of Communication 29 (Autumn 1979):137-144.

Telecommunications and Socio-Economic Change in the Pacific

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Abstract

There has been a tremendous impact of telecommunications on the socio-economic system in Trans-Pacific developed and transitional societies. In totality, however, with the change everywhere, even as the quality of human living has improved, the quality of human life has shown a disturbing imbalance. This imbalance is likely to be aggravated in the coming Crowd Age. This Paper attempts to identify the emerging socio-economic ills, and suggests a telecom strategy to meet the challenge.

Development is change. Old order yields place to new, and traditional societies shed their form and character, with passage of time. But all change is not development, and therefore the challenging process of development needs a modulation of change. One of the important instruments of such modulation is technology, which acts as a catalyst to changing patterns and systems. And among the technologies, telecommunications today ranks as one of the most powerful.

The status of telecommunications, in terms of facilities for socio-economic communication, differs from country to country. But broadly there are two situations -one where the facilities available are above the normal and the other with facilities below it. In the Trans-Pacific region, in the first category of highly developed societies, fall the United States, Canada Australia, Japan, Taiwan, and the city states of Hongkong and Singapore, and in the second category of transitional societies, falls the large group of countries comprising Thailand, Indonesia, Philippines, China, India, Mexico, etc.

In 1973, the United States, with a population of 203 millions, had 138 million telephone subscribers, 368 million radio receiver sets, and 110 million TV sets, which corresponded to 700 telephones, 1800 radios and 550 TVs per 1000 persons. In Canada, with a population of 23 millions, in 1975, against a total number of 6.7 million households, 6.6 millions were with radios, 6.5 millions with TVs. and 6.5 millions with telephones. In Australia, with a population of 13 millions, there were 2.8 million radio licences, 3 million TV sets and 5 million telephones.(1) In a tiny country like Japan, there were 28 million radio subscribers in April, 1979 with Nippon Hoso Kyokai, the public broadcasting organization alone, which now maintains as many as 5730 TV, 314 Radio and 474 FM transmitting stations (2), with 550 radio and 220 TV sets per 1000 persons. Even the city State of Singapore had over half a million TV receivers and around 11 million radio receivers in 1977

On the other side, in India in 1978, with a population of over 600 millions, there were 2.2 million telephone subscribers & 84 radio transmitting stations and 18 TV broadcasting and relay centres covering around 20 million Broadcast Receiver Licences (BRL) and 0.5 million TV sets.(3) Thus, the number of BRL was less than 1 set per 30 persons and that of TV less than 1 set per 1000 inhabitants. In Thailand, at the beginning of 1977, there were 6 million radio receiver sets and around 1 million TV sets.(4) In the same year Philippines, with a population of 37 millions, had 131 telephone exchanges with over half-a-million subscribers. There were 239 radio and 26 TV stations, with 1.4 million radio sets.(5) In 1978, the Republic of Korea had 2 million telephone subscribers meaning thereby 64 telephones per 1000 persons. And in 1979, Indonesia had 9 TV Studio Centres and 1 million TV sets, meaning thereby 1 set for 76 pefsons (6) In Malyasia and Bangladesh, telecommunications has a low level of sophistication as well as dispersal. Even today Bangladesh, with a population of 90 millions, has only two radio and six TV Broadcasting stations. In other words, as contrasted with a high spectrum-coverage of the socio-economic system in the former, in the transitional societies of the Pacific the presence of telecommunications is more of an apology than a facility

Table I
Telecom Facilities in Selected Countries of Trans-Pacific

Year & Population	TVs	Telephones	Radios
Category I			
1.U.S.A. (1973)	110 millions with 550 per 1000 persons	138 millions with 700 per 1000 persons	368 millions with 1600 per 1000 persons
2.Japan (1978)	5730 Centres -200 per 1000		314 radio stations & 550 per 1000
3 Canada (1975) 23 millions or 6.7 million households	6.5 million households	6.6 million households	6 5 million households
4.Australia(1974)	3 million sets	5 million subscribers	2.8 million BRL
5.Singapore(1977)	0.5 million sets		11 million sets
Category II			
1.Philippines (1977)	26 Stations	0.5 millions	239 radio stations & 1.4 million sets
2.India (1978)	18 Stations and 0.5 million sets with less than 1 per 1000	2.2 millions	84 radio stations with 20 million BRL with 33 radios per 1000
3.Thailand (1977)	7 TV sets per 1000	N.A.	78 radios per 1000
4.Indonesia(1979)	9 TV Centres with 1 million sets	N.A.	N.A.
5. Bangladesh(1978) 90 millions	4 TV Stations	N.A.	2 radio Stations

There has thus been, and continues to be, a wide disparity in the availability of even basic telecom facilities, like radio, telephones and TVs, between the two categories of the countries of the Pacific.

The Socio-Economic Impact:

Corresponding generally to the two categories of status of telecommunications, has the socio-economic development in the countries taken place. Without going into the cause-effect relationships, it will be seen that the telecommunicationally highly developed countries, have in the process of change, exhibited a few common trends. There has been a massive increase in the use of telecom facilities and equipment for business as well as social purposes, although proportionately urban centres or their satellite towns have taken the cake. The increasing demands for consumer and other items of telecommunications has accelerated the rate of industrial and commercial growth, including an increased emphasis on exports as a valuable outlet for production at home. The desire and the need for intense speed, accuracy and efficiency, necessitated by the machine age, has produced a highly efficient business machine, packed with computers, data processors, audio-visual equipment and distance-communication aids. With the 'laissez faire' policy of economic growth, and the resultant fierce competition on price and quality, there has been a virtual race for still greater technological sophistication. And finally, a cumulative result of all this has been a very high (getting increasingly higher) level of incomes and wages and standards of living. Telecom facilities in the developed societies of the Pacific have produced a very fast and efficient economic system, with an urbanised and commercialised social bias.

In the second category of transitional societies, telecommunications has established its need aswell as its benefits but the advantages, from the socio-economic point of view, have not sufficiently percolated down. About four-fifth of the population lives in the rural areas, dependent on the primary sector of agriculture, but more than four-fifth of telecom facilities are concentrated in non-rural areas. While improving efficiency in business and commerce, and accelerating the pace of technological change, through media exposure, in concentrated urban centres of growth, socio-economic life of these societies has been rather confused. The high cost of these facilities has created a widening schism between the few who can afford them and the mass that cannot, and hence does not use them. There is consequently a wide disparity in incomes and wages and standards of living of these two segments, creating a clash between the two principles of economic development and social justice. Sophistication is a far cry in social services net-work, and the dispersal and use of these facilities pose serious techno-economic problems. Thus, although the benefits of telecom technology do not seem to have been either widely shared or optimally availed of in these transitional societies, the deficiencies of the socio-economic environment seem to have been exposed and its defects highlighted.

Thus, as telemedia has penetrated the socio-economic system, it has indicated a complex impact that is both beneficial & baneful. This dichotomous impact on the developed and the transitional societies of the Pacific can be better understood through a comparative picture (Table II). It is obvious that there is a marked difference in the degree and nature of this impact on the two categories of socio-economic systems, with a more baneful impact on the transitional societies.

It needs to be noted however that this impact, in totality, has been not merely on the commercial and industrial sectors, but on the entire socio-economic fabric of the developed as well as the transitional societies. The group and the individual life including domestic and cultural values, social services like education and health, economic life including costs and quality of life - all these and many other aspects have got embroiled into the process of change.

We know, for sure, that in spite of a small proportion of time made available for educational programmes, TV has resulted in a phenomenal expansion of child and adult literacy. We know that radio has brought peoples and countries much closer both in terms of time and space, and has virtually revolutionized the information media. We know that telephone has resulted in intense economic activity and helped raise not only the levels and speed of business and commerce, but also assisted in cementing social and personal contact. The use of sophisticated and versatile equipments and techniques of communication. through satellite signalling, has opened up new vistas of technological possibilities. As a saver of energy, as a means of control, as an instrument of contact and as a medium of change, telecommunication has amply demonstrated its power.

But although telephone has enhanced the quality of lift, it has also been instrumental in creating a world of tension and

Table-II

Impact of Telemedia on the Socio-Economic System

DEVELOPED SOCIETIES	TRANSITIONAL SOCIETIES
1 A very fast rate of industrial and commercial growth and a marked trend towards export-orientation.	1. An accelerated rate of commercial and industrial growth, but restricted to selected points in the secondary and tertiary sectors.
2 A strong tendency towards urbanization, with a low percentage of population in the rural areas dependent on agriculture.	2. A marked concentration of facilities in urban centres, with an increasing population in the rural sector.
3 A modernized and highly efficient business machine and environment	3. A partly modernized, but inefficient business machine and system
4 A distinct movement towards still greater sophistication in telecom technology	4. A distinct dislike for sophistication and innovation, and a reluctance for dispersal of tele-facilities to social service net-work
5 A very high level of incomes, wages, cost and standard of living.	5. An inflationary pressure on goods and services, initiating high costs, with low levels of incomes wages and standard of living.

fast living. As TV proved its enormous value for entertain, its impact on adult and juvenile criminality has been too obvious to be ignored. As data processing and communication has reduced the possibilities of human error, it has also resulted in an increasing elimination of human hand, with concommitant problems of unemployment and misery. As radio has established itself as a universal informational media, it has added to the problems of world peace and tension. And so, with the change, even as the quality of human living has improved, the quality of human life has increasingly shown a disturbing imbalance.

Disturbing Trends:

The emergence of disturbing trends in the socio-economic fabric can be explained through a few significant developments. These are accentuated in the transitional societies particularly, where poverty, over population, economic backwardness and traditionality, compound the problems of economic growth and social change. Thus, with a greater dose of telecom technology:-

(1) Social conflict seems to take precedence over societal harmony. Bad news travels faster than the good news, & race and caste fights, communal disturbances, trade union strikes etc. receive more and quicker attention and importance.

(2) Physical comfort seems to take precedence over the ethics of usage. As the exposure through the media increases, there is a growing trend towards disintegration of the social value system. Social value system seems to be more than inversely related to the pace of telecom development, for even though the facilities touch the bare fringe of the populace, values seem to collapse all around.

(3) Political system indicates a growing resistance to opinion-tolerance, and hence, to democratic functioning. The more powerful the media becomes as an instrument of information-dispersal and opinion-building, the more effort goes into keeping it under the political control of the State. Autocratic behaviour and political violence are often offshoots of telecom progress.

(4) Profit seems to take priority over technological excellence or the concept of service and satisfaction. Trade restrictions, imposed by many countries, result in monopolistic trends, with the inevitable desire to make hay while the sun shines. Obsolescence or quality decay thus seem to percolate faster than the desire for innovative technology.

(5) Urban centres seem to corner the cream of development, leaving the large rural mass devoid of even basic facilities. The scarcity of resources acts as a powerful brake on the efforts to telecommunicationize the largely inaccessible rural areas. With the majority of the inhabitants living in villages, inequitable distribution of benefits to urbanites vis-a-vis ruralites results in an ever yawning schism between the two.

In the light of these disturbing trends, the need for modulating the process of future change becomes necessary. While the dangers arising out of the machine age multiply this necessity, the emerging social challenges, more especially in the transitional societies of the Pacific, make it urgent. Let us understand the nature of this continuing threat and the character of these emerging challenges.

The Crowd Age:

The Pacific Asia of the Eighties, and the Pacific America of the Nineties are going to have, what may be called, the Crowd Age. The score of years to turn the century are likely to witness seemingly insoluble problems of enormous demographic explosion, severe physical hunger, acute emotional stress and disintegration of family and social life. The baby boom, that continues in the transitional societies of the Pacific unabated, has created serious problems of not only feeding the teaming millions, but also of educating them and making provisions for healthy living. There is an ever-increasing pressure on the social services network and an increasing unfulfilled demand for education, health, communication, et al. In such an atmosphere, perversion of media, reflecting the ills of a decaying society in the wake of a developing technology, is likely to become the hallmark of change.

With the proliferation of tele-facilities, there is already a virtual scramble for radio and micro-wave frequencies. WARC notwithstanding, this pressure will increase with overcrowding of frequency spectrum. Orbit space congestion has also become too evident to be ignored. The crowded roads and airports of America point to another aspect of overcrowding.

With increasing exposure to the developed societies, there is already emerging a fantastic demand for tele-facilities in the transitional societies. The infra-structural base being insufficient, the facility-overcrowding is only a matter of time, giving rise in its wake to stupendous problems of logistics and operational management as also of quality control and utilization.

The Crowd Age has thus, telecommunicationally, three major dimensions, namely,

1. Human overcrowding - and resultant problems of feeding, entertainment, education and social contact;

2. Media overcrowding - such as radio frequency spectrum, orbit space, transport and business communication - and resultant problems of efficiency and economy;

3. Facility overcrowding-such as TV & telephones -and resultant need for infrastructural base and quality control.

This overcrowding is the source of emerging socio-economic ills. Add to this, the problems of scarce resources, continued intolerance and past non-performances, and we have before us a really challenging tableaux. Sooner than we think, the entire Pacific socio-economic system may come under severe strain, and increasingly prone to breakdown, in the face of ever-widening gaps between promise and performance, ability and achievement, need and availability. Never before has the Pacific been in such a ferment, and yet never before has such an opportunity existed to harness the resources of the region.

Bridging the Gap:

For, with the powerful instrument of telecommunications, it seems much quicker and easier today to grapple with these emerging ills in a concerted, integrated and effective manner. In this regard, what we need is to identify the objectives & adopt a suitable strategy.

Telecom objectives have to be identified keeping in view the objectives of human development and the satisfaction of human needs. From the point of view of telecommunications, human needs could be grouped into three parts - the Basic, the Social and the Para-Physical. The basic needs have to be accorded a higher priority in setting the telecom objectives, but an inter se priority between Social and the para-physical needs is a difficult exercise. In the Crowd Age, there may be an increasing need to temper the telecom strategy with some of the requirements of the para-physical needs, over those of social needs.

Table III
Human Needs and Telecommunications

Basic Needs	Social Needs	Para-Physical Needs
1 Hunger	1. Physical Needs of living	1. Ethical Values
2 Illiteracy	2 Social Services	2. Adventure
3 Health	3. Commerce and Business	3. Mental Peace
	4. Peaceful Co-existence	4. Ecological Balance

Based on these human needs, the existing statii of telecommunications and the demand for an integrated effort, the areas that would need to be accorded high priority henceforth can be classified into three major groups, namely, technological development and transfers, rural telecommunications and social services.

There is a lot of talk these days of appropriate technology but little guidance is available as to the appropriateness of any technology to given circumstances. There is a race for sophistication and higher levels of telecom technological achievements, meaning thereby quicker, easier & in the process, often costlier techniques and models. Technological excellence has almost become synonymous with complexity and almost an end in itself. To most of the countries of the Pacific, this would be quite inappropriate to the needs. Who may need video telephones, when there is a large queue lasting years to get an ordinary telephone connection? Who may be interested in colour TV, when even black & white TV is a luxury concentrated in a few pockets? And why? What perhaps we need is, like in America, a telephone system and a TV network, so cheap and widespread that most can afford, equipment and items that can be easily operated and used, services and facilities that provide moderate efficiency at low cost, and a telecom system that can be widely dispersed and easily and quickly made available on a large scale. The approach to technological development and transfers has to be geared to this.

It is an irony of situation that with four-fifths of their populations living in rural areas in most of the countries, less than one-fifth of telecom facilities are available to them. And this by design, for the system has a predominantly urban bias. The traditional approach to transmission media in most countries is to provide high cost-and-time consuming ground-to-ground point-to-point line system. This obviously means enormous requirement of funds and enormous length of time, which one can ill-afford. What is needed is a shift of emphasis from the wired society to the wireless society. With proper checks and controls,and with transmitting satellites to back up, wireless seems to offer the most economic,quicker and widespread use of telecom facilities. Again, instead of video telephones, mobile telephones, like TVs and radios, so common in USA and Japan, can be a major catalyst for rural development through instant contact almost anywhere.

The third major priority area would be the social services, like medical and health, transport and communications, education & entertainment. The problem of over-crowding in hospitals, banks, schools,railways and buses, cannot be visualized by the people living in the USA, or even in Japan. One has to see the congestion and inefficiency to believe it. The quality consequently is a casualty all around. This is further aggravated by the poor quality of infra-structure of social services, & is often confounded by ideological considerations. The quality of telecom facilities available in some countries, notably USA, establishes the technological and administrative feasibility of such facilities elsewhere too, initial problems notwithstanding. This technological feasibility need no longer remain a wishful dream.

Telecom Development Strategy for Pacific:

The strategy, in the context of developing Pacific as a region, for which indeed there is no alternative, will entail a four-pronged concerted drive:-

(1) Creating of a Pacific Telecom Authority;

(2) Integrated Telecom Policy-Making for the Region;

(3) Agreement on principles of Development and Technological Transfers; &

(4) Establishment of Service Grids and Networks.

At the Last Year's PTC, I had submitted a case for international monitoring and funding to accelerate and modulate the pace of telecom development in developing countries. In view of the inherent problems of ideology and resources, that seems to be a distant dream. A regional authority like the Pacific Telecommunications Authority, would seem to be a more feasible proposition, especially if funding is not an integral part of this Authority. The greater is the sophistication in the advanced countries of the Pacific, the greater is the hiatus between them and those in the transitional stage, and the greater the need for such a coordinating Authority.

The role of this Authority could be precisely to lay down the policy of telecom development in the region,including the principles of technological transfers, the sharing of telecom facilities, the structure of prices and models and the establishment of regional service grids and networks Exploration of new frontiers, and sharing of new developments could be another area requiring its attention. Guidelines for modifications in national policies and priorities may also form one of its important briefs. And it will have to be charged with the power and the responsibility to resolve claims on the use of orbit space and radio frequency spectrum and to enforce multilateral agreements for technological transfers and collaborations

Technological transfers are necessary in a shrinking world, and with this necessity arises the need for a fair deal to both the transferer and the transferee. Commercial benefits are durable only when there is a fairness in dealings. The monopolistic situations, inherent in telecom technology, tend to generate a feeling otherwise. They also create an aura of distrust. Since interests often tend to clash, some principles and guidelines for technological transfers need to be jointly evolved. The proposed Pacific Telecom Authority will be presumably best suited.

And lastly, the establishment of service network of facilities, linking hospitals, banks, libraries and such other social service institutions in the entire region will indeed be soon an essential feature of the attempt at integration. Even now international trunk dialing system is operating in a number of countries and satellites are covering the entertainment media irrespective of geographical boundaries. I understand the difficulties involved in this arrangement, but once the realization sets in that such services are not only mutually beneficial, socially and commercially, but also desirable for the whole humanity, things will fit into the desired pattern.

This then is the Model that I present in Fig 1. We control the ills of socio-economic change in Pacific arising out of telecommunications, by using telecom as the instrument of modulation of change. It is by identifying human needs, by forecasting emerging challenges, by according suitable priorities, by adopting an integrated strategy and by establishing a Monitoring Authority that the challenge of the coming Crowd Age can be adequately met. And we need to do this fast.

The Question Why?

Admitting that emerging social challenges in the under-developed societies of the Pacific need attention of telecom engineers and planners, why should the countries that have nothing to gain in the process, participate in this endeavour? Especially if they are expected to foot the bill also? A very valid question indeed! For prima facie, it would seem to be absurd to ask the developed societies to participate in the development process of the transitional societies. Self-interest would seem to dictate a policy of keeping aloof, a policy that America followed a century before.

And still, it is precisely this self interest that is the primary reason for a policy of active participation. In course of time, we would eventually realize the raison 'd etre of a Pacific Development Plan of integrated action. The countries of the Pacific are separated by a vast ocean, but are hardly more than half-a-day away by air. Through telecommunications, they are not even half an hour away. The news, especially the news of violence and conflict, travels faster than ever before, and produces adverse impact on societies everywhere. Business boom in developing societies opens up new overseas markets for the export of industrial production of the developed societies.

In an increasingly shrinking world, nations cannot afford to remain within their tortoise shells. The greater the disparity between the developed and the transitional societies, the more does the tele media accentuate it. And the more does it become necessary for the haves to share it with the havenots. A time will soon be there when the third segment of the Pacific - the super-developed America and Japan - in their own interest will not only have to bear the white man's burden, but also bear the responsibility of bringing the socio-economic change necessary to lighten it. Revolutions do not stop at nations' boundaries, nor does economic affluence insulate nations against socio-economic disorders and discontent elsewhere.

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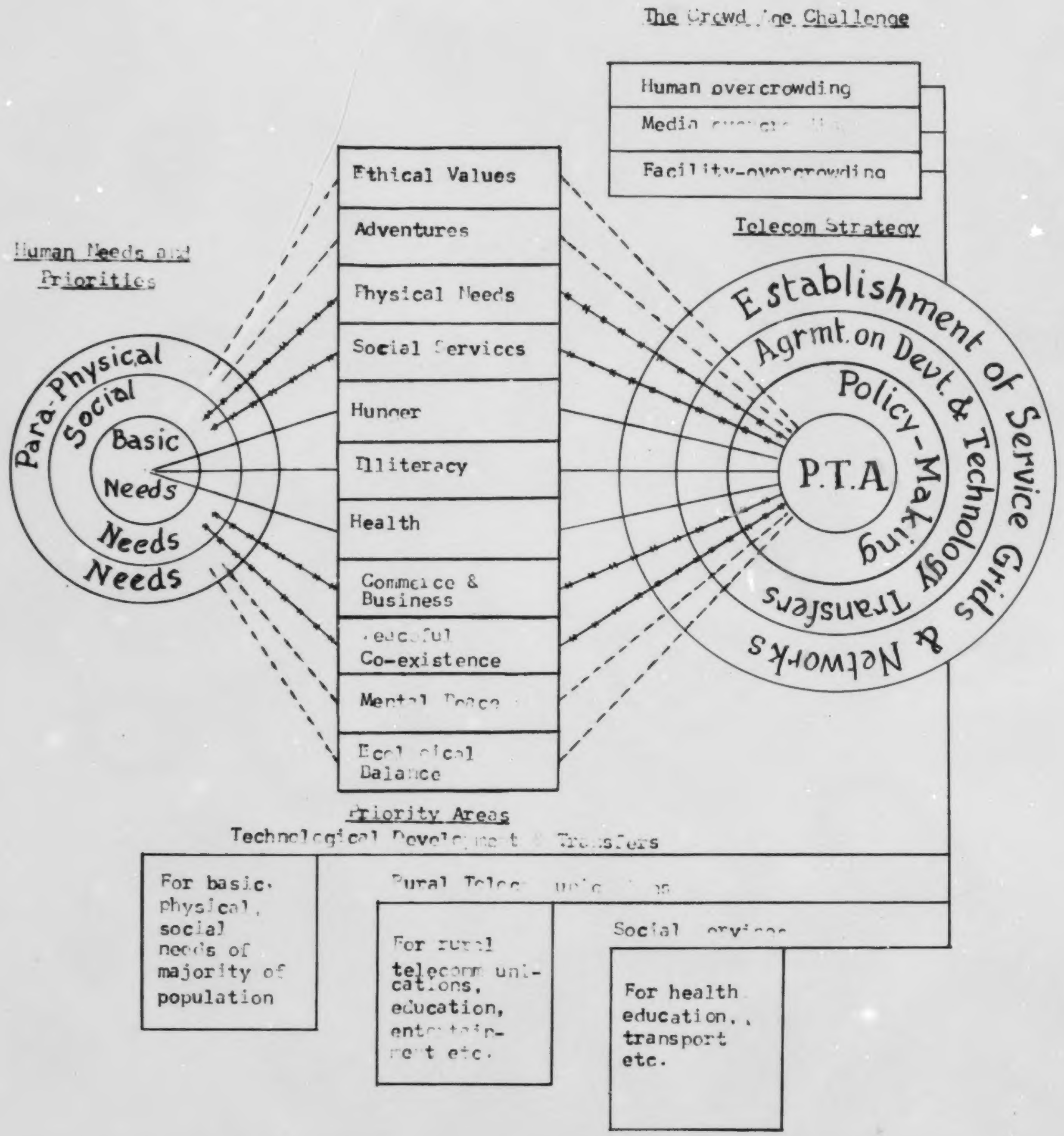
Fig 1

HUMAN NEEDS, CROWD AGE AND TELECOM STRATEGY


The Crowd Age Challenge
Human overcrowding
Media overcrowding
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Telecom Strategy
Human Needs and Priorities
Para-Physical Needs
Social Needs
Basic Needs
Ethical Values
Adventures
Physical Needs
Social Services
Hunger
Illiteracy
Health
Commerce & Business
Peaceful Co-existence
Mental Peace
Ecological Balance
Establishment of Service Grids & Networks
Agrmt. on Devt. & Technology Transfers
Policy-Making
P.T.A
Priority Areas
Technological Development & Transfers
Rural Telecommunications
Social Services
For basic, physical, social needs of majority of population
For rural telecommunications, education, entertainment etc.
For health education, transport etc.

NTIA's Role in International Telecommunications

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Abstract

Following the dramatic changes in the provision and regulation of U.S. domestic telecommunications services NTIA has sought to develop policies which can extend these policies to the provision of international services. Extension of these policies, however, must consider the cooperative nature of international telecommunications. Nevertheless, the U.S. must take actions, legislative and executive, which will assist the U.S. service provider and telecommunications user abroad by promoting additional competition which can result in more service offerings, lower rates and greater flexibility for users.

The National Telecommunications and Information Administration was created in 1978 to act as the President's chief policymaker and spokesman for all aspects of communication and information policy. Within NTIA the Office of International Affairs is responsible for policy development and advocacy in the international field.

Our immediate goals in international telecommunications policy are threefold. The first is to develop, propose, and apply consistent U.S. telecommunications policies and positions that promote fair competition and greater reliance on marketplace forces. The second is to examine the merits of and make recommendations for change in the existing U.S. international telecommunications industry in order to increase the availability of both basic and enhanced services. The third is to assess the opportunities for introduction of new technologies and services into international telecommunications.

In the past few years, there have been dramatic changes occurring in the provision and regulation of domestic telecommunications services within the United States. Now, NTIA is seeking to extend the U.S. policy of competition, deregulation and reliance on marketplace forces to the provision of international services as well. As a result there is a veritable explosion of interest in the rationale for such steps as well as concern and curiosity as to the likely outcome.

I'll take this opportunity to give you NTIA's perspective on the issue--and I won't hesitate to give a personal perspective as well.

I am a former regulator. For six years at the Federal Communications Commission, I worked to carry out the mandate of the Communications Act of 1934, an arcane document which has been described as the zenith of abdication of Congressional responsibility to a U.S. regulatory agency. This law was passed during the New Deal era, when it was believed that to ensure the welfare of U.S. citizens extensive governmental supervision over numerous private activities was required.

The common carrier area was perceived as appropriately the domain of a natural monopoly, and thus regulatory controls were enacted to provide for rate-base regulation--that is, the Commission would pass upon common carriers' applications to make capital investments, ostensibly determining whether such investments were required in the "public interest" and thus permitting the carriers to earn a specified rate of return on investment. This scheme was designed to insure fair investment opportunities in the privately held, regulated companies and to assure ratepayers of reasonable rates. The system of rate-base regulation meant slow but steady progress. I wasn't around in the 1930's, or for that matter the '40's, '50's, or '60's, so I cannot provide insight into the success of the system in those decades. But, by the 1970's, it was apparent that the telecommunications industry was beginning to bust the seams of the 1934 Communications Act.

Although the 1934 Act in a sense applied the same regulatory requirements to international as well as domestic communications services and carriers, it did not address specifically any of the peculiarities of the international market. More as an effort to provide a means of ensuring a viable domestic telegraph industry than as an attempt to rectify this gap in the original law, the addition of Section 222 in 1943 addressed international communications by dividing international and domestic markets and provision of voice and record services. This new section essentially froze market shares in the provision of international services as of that time. It has added a layer of complexity, and increasing absurdity, to regulation of the international sphere.

An additional element, further complicating the international environment, was the enacting of the Communications Satellite Act of 1962. That Act, as well as U.S. policy, necessitated regulatory actions which would encourage the development and use of a global satellite system.

While those of us who specialized in international telecommunications were valiantly struggling to adapt the Act to the international environment, dramatic advances were being made in the domestic area. Efforts to stimulate the marketplace in domestic telecommunications had been taking place over a number of years, with permitting connection of customer-supplied terminal equipment signalling the advent of numerous other procompetitive actions to come. 1/

Following the Commission's landmark decision in Carterfone, in which it established the principle that such interconnection of customer procured equipment should be permitted if "privately useful without being publicly detrimental," the Commission sought to encourage provision of innovative services tailored to special needs of users by authorizing provision of private line services by carriers in addition to AT&T and Western Union. 2/ The Commission believed that permitting the entry of new common carriers into the U.S. domestic marketplace would expand the availability of new services, giving consumers greater flexibility and a wider range of choices among offerings. This was seen to be particularly crucial for data communications users whose requirements were based upon a need for computer compatible digital technology. The Commission expected that the introduction of competition would stimulate technical innovation, the introduction of new techniques and the development of new services to meet previously unsatisfied consumer demand.

The last ten years have shown that the Commission's expectations were modest. We have witnessed a responsiveness in the U.S. domestic marketplace which exceeds the prophecies made in the beginning of the decade. A catalogue of benefits to the U.S. consumer would include improved service quality and lower costs, as well as the expansion of the marketplace itself. Technology has driven competition and has, in turn, blossomed. New services now being offered--or proposed--include some of a highly innovative nature and the use of sophisticated computing equipment for switching which has allowed the introduction of a host of specialized services. Many analysts recognize that the boom in our information industry is due in no small part to regulatory actions designed to spur innovation.

While the benefits foreseen by the Commission from its Specialized Common Carrier Decision have clearly come to pass, the detriments predicted have not. Opponents of new entry argued that "cream skimming" would cause a substantial--and severely detrimental--diversion of revenue. However, in its investigation of the economic impact of competition, the Commission has not found any detrimental impact which would require a reexamination of its procompetitive policies. 3/

Interestingly, the Commission's authorization of entry by a specialized common carrier, MCI, has led to competition in the provision of domestic MTS and WATS service, a result not originally contemplated by the Commission in authorizing MCI's EXECUNET service, which was characterized as a private line offering. In a fascinating chain of legal events, the Court of Appeals found that the FCC could not restrict the scope of MCI's offering in terms of services without providing explicit public reasons for so doing. 4/ In order to resolve the general question of whether it was in the public interest to require provision of MTS and WATS service on a monopoly basis, the Commission instituted its MTS/WATS Inquiry 5/ in which it recently concluded that there was already competition in the provision of these services, without detrimental public impact.

Following its Specialized Common Carrier Decision, the Commission initiated its policy of open entry, open skies in the provision of domestic satellite service. From my perspective, while heading up the International and Satellite Branch at the FCC, the contrast between development and innovation in the domestic satellite industry and our hamstrung efforts to further innovation in the provision of international services became increasingly apparent. While numerous vendors sought authority to build, launch and utilize domestic satellites for private line, data services and video transmission, we were hard pressed to authorize one or two additional entrants in the international area. A colleague of mine at the FCC said that one of the reasons for successful implementation of the domestic satellite policy was the fact that the processing staff for these applications generally included no more than one attorney. There may have been some truth to this observation. However, in the international area, our staff was burdened with the Section 222 of the Communications Act, case law requiring assessment of competitive impact, as well as carriers--and attorneys--well skilled in the art of filing pleadings to protract consideration of any application perceived as a "competitive" threat.

Thus, while the last decade witnessed dramatic advances in the U.S. domestic telecommunications market, the international marketplace was not comparably stimulated. Demand for new service offerings had not grown as quickly and advances in technology have not been implemented as rapidly as in the domestic marketplace. Nevertheless, the picture is changing. We can foresee that as more consumers come to rely upon sophisticated and innovative services offered domestically, they will demand that these services be offered internationally as well.

We have seen evidence of that phenomenon in the last few years. In February of 1976, an application was filed by Graphnet Systems, Inc., for authority to introduce a new facsimile service between the United States and European points. In May, Telenet Communications Corporation filed an application to provide its public packet-switched data communications service between the United States and the United Kingdom. Both Graphnet and Telenet operated within the domestic United States and sought to extend the availability of those services offered domestically to international points.

The Commission found that the applications were in response to a fast growing need for overseas data communications services which was not being met by existing service offerings. 6/ Relying upon the independent projections of the future of international telecommunications, the Commission foresaw phenomenal growth in the number of data terminals in use--and the consequent need for efficient international data communications services.

Although Graphnet and Telenet do not now offer their services directly, international services such as they proposed in 1976 have become available through interconnection with the U.S. international record carriers and their foreign correspondents. In fact, interactive computer-to-computer services have now been introduced between the United States and a host of other countries, reflecting a significant demand for these services. To be specific, combined IRC revenues from interactive data services have grown from $118,000 in 1977 to over $1,000,000 in 1979. Preliminary 1980 figures show continued substantial growth. That demand clearly stems from the reliance on such services provided domestically, both within the United States and other countries. As other new services develop domestically, we can expect that demand will increase for the provision of those services internationally.

To respond to those needs NTIA has developed policies which flow from our observation of the domestic environment but which recognize the cooperative nature of international telecommunications. We have advocated these policies before the Congress, before the FCC and before audiences like this one. I have no pretensions about success. While the FCC seems to agree with many of our recommendations and has, since last December, been attempting to implement many of the suggestions we made to Congress in our 1979 testimony, the era of competition and deregulation in the international field has not yet dawned. Not only are these policies facing chilly winds from abroad, they are also getting a cold shoulder in the court. Many of the Commission's recent efforts are undergoing legal challenge, and in August of this year the Second Circuit Court of Appeals ordered the Commission's order permitting Western Union to provide competitive international service to be vacated. I cannot predict what the outcome of these challenges will be. None of us can. The only thing about which we can be certain is that we face an era of uncertainty unless we revise the Communications Act of 1934.

The 1934 Act is no longer adequate as a statement of U.S. national policy. The events of the last ten years in the domestic marketplace have shown that a national policy favoring competition in the provision of telecommunications services can now bring significantly greater benefits to the consumer than a national policy favoring regulation. Only by stretching the law to its limits have we made the strides we have domestically. Almost all observers of the domestic scene now agree that some changes are necessary to accommodate the industries grown so large and dynamic. If Congress fails to make these changes, the inevitable consequence will be a continuation of a long series of disruptive regulatory and court challenges which will find telecommunications policy being established by our judiciary system under the inadequate guidance of an outdated statute.

The same criticisms apply even more poignantly to the international sphere. As U.S. domestic industries grow, the pressures to accommodate that growth internationally will become more acute. Not only does the existing law constrain innovation and flexibility both domestically and internationally, it also fails to provide a scheme for the recognition of the mutuality of international telecommunications.

In May 1980 the Commission instituted proceedings which expressed its tentative belief that resale and sharing of services should be extended internationally and that COMSAT should be permitted to offer retail satellite services. 7/ These comtemplated actions highlight the fact that provision of international telecommunications is a cooperative venture between nations. This fact has been noted in numerous comments filed in these proceedings, and was discussed extensively in NTIA's own filing in the International Resale proceeding.

Following the authorization of Graphnet and Telenet to provide international service, we have witnessed the reluctance of overseas correspondents to consider the introduction of either new carriers or new services. The provision of international communications is a mutual undertaking: no partner can unilaterally introduce a new service and no new carrier can operate without at least the tacit acceptance of the correspondent. There may be many reasons for reluctance on the part of our correspondents, including a desire to be convinced of the economic and technical feasibility of a service or an urge to allow development of a domestic industry.

At NTIA, we respect these policies, as we hope that our policies are equally respected. In fact, we are seeking revisions of the 1934 Communications Act that will provide a framework for mutual respect. Changes in the Communications Act of 1934, when they come--and they will come--

will include changes in the approach to international telecommunications. You will see a clear statement of national policy favoring competition; you will see a recognition of the cooperative nature of international telecommunications; and you will see specific revisions designed to create a more flexible environment for our service providers and a more beneficial environment for our consumers.

I don't know how long it will take to accomplish these changes, but I'm certain they'll come. After all, it took 20 years from Hushaphone to the Terminal Equipment Registration Program. We need only be pateint and remember Disraeli's words: "Constancy of purpose is the secret of success."

Footnotes

(1) See *Hush-a-Phone v. U.S.*, 238 F. 2d 266 (D.C. Cir. 1956), and *Carterfone*, 13 FCC 2d 420 (1968), recon. den. 14 FCC 2d 571 (1969). See also *North Carolina Utilities Commission v. FCC*, 537 F. 787 (4th Cir. 1975), *cert*. *den*. 429 U.S. 1027 (1976).

(2) See *Specialized Common Carriers*, 29 FCC 2d 870 (1971), *aff'd*. *sub* *nom*., *Washington Util. & Trans. Commission v. FCC*, 513 F. 2d 1142 (9th Cir. 1975).

(3) For a comprehensive discussion concerning the impact of permitting competition in the provision of terminal equipment and private line services, see *Customer Interconnection*, 61 FCC 2d 767 (1976) and 75 FCC 2d 506 (1980).

(4) *MCI v. FCC (EXECUNET I)*, 60 FCC 2d 25 (1976), 561 F 2d 365 (1977), *cert*. *den*. 434 U.S. 1040 (1978). *MCI v. (EXECUNET II)*, 580 F. 2d 590 (1978), *stay denied* 436 U.S. 915 (1978), *cert*. *den*. 439 U.S. 980 (1978), wherein the Commission was required to order AT&T to interconnect with MCI for provision of its service.

(5) 67 FCC 2d 757 (1978), 72 FCC 2d 222 (1979).

(6) See *Graphnet Systems, Inc.*, 63 FCC 2d 402 (1977), *recon. den.* 67 FCC 2d 1020 (1978).

(7) *International Resale and Shared Use*, CC Docket 80-176, FCC 80-220, released May 19, 1980 and *Authorized User*, CC Docket 80-170, 77 FCC 2d 148 (1980).

Alternative Strategies for Managing Orbit and Spectrum Resources -- Third World Demands for Domestic Satellite Service*

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Abstract

This paper considers alternative strategies for managing mainly orbit spectrum first, by identifying major factors that contribute to rising Third World demands for same, and second, by reviewing the alleged economic costs of orbit spectrum planning, as well as economic distortions attributed to first come, first served. Within those polar bounds, it concludes by examining some promising scenarios for clues to how developing and developed nations may arrive at a modus operandi which reconciles their seemingly divergent economic interests.

1. Factors Contributing to Rising Third World Demands for Orbit Spectrum Allotments

The rising Third World demand for guaranteed access to orbit spectrum may be attributed to unequal expertise of the negotiating partners in advanced and less developed countries, resultant suspicions of the facts on which experts in advanced nations urge less developed ones to agree to base allotments, Third World fears of recurrent latecomer impediments (as in HF spectrum) to preferred orbital slots and space satellite spectrum if LDC claims are not now asserted, the appeal to LDCs of detailed pre-engineered orbit spectrum plans (as enunciated for Regions 1 and 3 in 1977) to assure their future access.(1)

The specter that advanced nations now confront in continued development of telecommunications technology is one of unused orbit spectrum rights held by LDCs which ostensibly seek to (a) humiliate advanced countries for socio-psychological reasons of national prestige, (b) win leverage for political concessions in other arenas (in North-South confrontations), (c) construct and operate their own telecommunications systems at some future point, however long it takes, or (d) secure a domestic broadcast, voice, and data service incorrectly presumed to require LDCs themselves to use their implied rights to provide.(2) One fundamental question I want to consider is whether, and if so how, advanced countries like the U.S. can offer developing nations the kind of domestic service the latter ostensibly seek in exchange for orbit spectrum rights*** they may never use.(3)

2. Reputed Economic Costs of A Priori Planning

Among the reputed costs of an a priori orbit spectrum plan for advanced countries (HDCs) are said to be: (a) 'chilling' effects on satellite technology development, (b) barriers to new satellite systems and conceivably to competitive systems even within an advanced economy with potential markets to support them (as in the U.S.), (c) long periods of unused and unoccupied parking slots and orbital spectrum for LDCs with the votes to distribute assignments for all nations on a pre-planned basis.

Detailed a priori assignment plans, though ostensibly geared to safeguard latecomer access by less affluent LDCs, may, in their present form at least, ironically go far to (a) intensify orbit and spectrum congestion for those advanced nations with the know-how and wherewithal to proceed, and (b) impair at least some of their capacity and incentives for basic innovation.

Furthermore, the LDCs' current version of a priori planning may deprive them of any near-term share of associated economic rents, and hence of vital resources to develop their own telecommunications infrastructure. The economic analysis of orbit spectrum resources can therefore help us first, to define rights at once less ambiguous and more enforceable, exchangeable, and leasable than hitherto, at lower costs, and second, to better reconcile the competing goals of economic efficiency and distributional equity associated with orbit spectrum utilization.

From still another viewpoint, concerted LDC actions to reserve orbit spectrum could raise its marginal value to the U.S. far higher than under an evolutionary regime of first come, first served. The rising economic value of orbit spectrum at the margin would be reflected in sums the U.S. would hypothetically be willing to pay to acquire additional rights (from LDCs or ITU), or in the cost of political 'deals' it might be willing to make. If so, just as OPEC nations are 'poor' but 'resource rich,' and restrict U.S. access to oil under their lands (whose value is clearly more affected by U.S. and advanced economy demand than by their own capacity to use it), so, too, LDC ability to extract economic value for orbit spectrum is enhanced by their ability to restrict access by the U.S. and other HDCs.(4) The oil resources were always there, physically, that is; only the technology and know-how were lacking to develop them, and so, too, with the orbit spectrum resource.

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***See comment at end of Footnotes.

3. Reputed Distortions Under First Come, First Served

Before proceeding to some middle range options within the above context, a word first on economic distortions often attributed to unfettered use of a common property resource, and in particular on so-called "common pool" and "free rider" problems. A central task in managing the orbit spectrum today is to correct the former without inadvertently exacerbating the latter, or ignoring politically potent Third World demands for a "fair share."

A. Common Pool Inefficiencies

Common pool problems arise in ocean fisheries, water sheds and oil pools though possibly less with deep sea mineral nodules. None of these common pool resources is owned by individual firms or countries, or if so owned, exclusive property rights are not enforced. There may therefore result "excessive" investment and production, i.e., economic waste. In these so-called fugitive resources, no owner/user benefits by postponing use since that would only act to lower the costs of rival users of same, and in no way operate to increase his share of total output. Thus all users will tend to overutilize, overdrill, overfish. For fear that rival users would otherwise recapture the output any single user forgoes, therefore, all users will tend to overutilize, overdrill, overfish, or overpump, thus raising the costs to each other.(5)

Similar common pool inefficiencies arise in the use of orbit spectrum and HF radio frequencies in particular.(6) Under the present evolutionary regime at least, LDC latecomers believe that if they do not now assert claims, advanced nations with the technology and know-how to proceed will most certainly do so. Even with rights they cannot now use, that is, LDCs hope to better share in benefits tomorrow than if, failing to assert claims today, they later find themselves precluded. All this tends to impose higher costs on developed countries which may as a consequence have to innovate orbit economizing technologies that are, strictly speaking, uneconomic.

B. Free Rider Problems and Economic Incentives

Just as common pool problems may notably result in "too much" investment, exploitation, and production, too soon, so the problem of free riders may result in "too little," too late. A classic example here arises with public goods generally, associated with benefit externalities so diffuse and hard to trace that all who enjoy them cannot be charged directly, nor deprived of access if they don't pay. Another example relates to technological advances costly and risky to bring about but which could be readily and cheaply copied by imitators but for patent protection without which innovators are reluctant to proceed.(7)

In the instant case, the free rider phenomenon is best identified by asking: Will HDCs continue to develop orbit spectrum without internationally recognized vested rights, given that latecomer LDCs would inevitably share in the technical advances at a later point? Or does the regime of first come first served, and the HDCs' big head start, now virtually insure them the chance to earn enough more than LDCs to pay for the research, innovation, and development without explicit protection against LDC free riders?

In effect, investment in new technology for fuller exploitation of the orbit spectrum resource will be sub-optimal where an HDC fears it cannot fully appropriate the resultant benefits. A developed nation would clearly refrain from investing as much, or as quickly as otherwise, if it feared that other potential spectrum or orbit users (HDC or LDC) would stand to benefit at lower development and search cost to themselves, at the first country's expense.

By the same token, an LDC will also be reluctant to invest in spectrum economizing equipment modifications (as in converting from double to single sideband in HF radio), unless somehow guaranteed that it, and not the advanced industrialized nation, will have access to the released HF frequencies, or otherwise be able to share in their resultant economic outputs. That is, the prospect of Western nations being spared the extra costs of higher transmission power (via the HF channels released by equipment conversion), without reimbursing LDCs for their new (SSB) equipment, is precisely the kind of "free riding" that economists see as deterring firms, or countries, from investing in optimal resource development.

4. Five Scenarios to Reconcile Divergent Orbit Spectrum Claims of Rich and Poor Nations Within the Polar Bounds of First Come, First Served and a Detailed A Priori Plan

Of paramount concern here, then, is to identify and examine the efficacy of alternative approaches to reconciling Third World demands for guaranteed future access to orbit arc and spectrum resources with pressing near-to middle-term Western industrial requirements for same. The additional question is how far these policy scenarios appear likely to correct so-called common pool inefficiencies under open access without seriously impairing the incentives and capacity for innovational advance.

A. Towards a Credible Guarantor Concept

This would be closest to the current evolutionary system of first come, first served. The world's leading spectrum users would essentially agree to "find" orbit spectrum for latecomers when the latter's technology, know-how, and domestic community needs had advanced to the point where they themselves could establish new domestic satellite systems.(8)

To make this option sufficiently credible for LDCs to agree to forego immediate claims on orbit spectrum (long before their technology would permit effective usage), the guaranteeing nations' seriousness of intent must be established by such initiatives as: (a) pledges to phase out or relocate satellite operations upon LDC request within a pre-determined time period, in light of a demonstrable technical-economic plan for LDC utilization; (b) tow-away zones; (c) a phased time vacating schedule.(9)

Though this option is clearly preferred by the U.S. to *a priori* planning, and closest to current practice, the question is whether a really *credible* set of safeguards for future latecomer access, e.g., stiff penalties for late withdrawal by advanced nations, can be devised without significant disincentives for the latter. Yet inferior LDC monitoring capabilities create such mistrust as virtually to require detailed safeguards in that good faith alone will not suffice.

The effects on orbit congestion and technological change appear as follows. By reassuring LDCs against future preclusion, a credible guarantor mechanism will act to reduce the congestion created by padded paper claims on the orbit spectrum by poor nations lacking the expertise and wherewithal to use it. In fact those nations' perception of past experience (with HF frequencies) is that developed countries will tend to preempt anything the LDCs do not lay at least nominal claims on (common pool problem).

But the net effects on communications technology are less readily categorized. As with detailed planning, HDCs may be deterred by knowledge that latecomer LDCs will benefit from the former's investment with no development costs of their own, and from progress the incumbents make before LDCs enter (free rider problem). Yet offsetting these disincentives, and clearly unlike the detailed planning case, are the perhaps substantial gains HDCs may reap during an undefined interim period when they will enjoy temporary but exclusive operating rights. Thus the incentive for free riding will be less here (as also in Option B) insofar as HDC and LDC users are inexpensively able to agree that *one* of them will have *exclusive* use of a particular spectral region, frequency channel, or orbital position, and where exclusivity is ideally worth the maximum either class of user would be willing to pay for it.

B. Leasing of Unused Orbit Spectrum

At the other extreme, just short of a detailed *a priori* orbit spectrum plan, stands the possibility of permitting the holders of unused rights to *lease* them to nations with the technology and know-how to develop, install, and utilize satellite communications systems.(10) This option accepts as virtually inevitable the LDCs' determination to impose some pre-engineered plan to safeguard latecomer access (given their deep mistrust of current practice and even of other provisions to accomodate them on a voluntary basis as under option A).(11)

Option B permits the LDC leaders to bring home symbolic success in wresting a "rightful" share of orbit spectrum rights with allegedly great economic value to others. But instead of presuming that only those vested with the rights can use them, Option B adopts a more realistic stance, one open to market incentives. Thus LDC rightholders lacking the technology and know-how to proceed would be permitted, indeed encouraged, to lease their orbit spectrum rights to the highest bidders for designated time periods.

Nations with advanced systems know-how and capital on the other hand, could thereby acquire the orbit spectrum rights needed to develop satellite systems for a wide variety of national and international purposes, at the same time paying the LDC rightholders growing lease revenues-cum-orbit spectrum rents, out of the gross system revenues generated.

A major obstacle to Option B, however promising it may at first glance appear, lies in the current practice of defining orbit spectrum rights in such detail as to render them virtually unusable by any nation *except* the one in which originally vested. Thus the power, orbit location, frequency, bandwidth, antenna beam, directivity, etc., each nation was authorized to use at the Broadcast Satellite Conference in 1977 were specified so narrowly that there were few alternative uses or users for which they would be suitable. To facilitate the prospects for Option B, therefore, we must first and foremost define orbit spectrum rights so as to make them far more transferable than today.

Once again, orbit spectrum congestion will be less than under the current open access regime, but not (as with detailed planning) for the LDCs alone. Here as with Option A, developed countries can arrange to use unused LDC rights (as well as their own), and hence enjoy relief from shortages of the latter. Prior knowledge of this might reduce the LDCs' immediate demands for access rights (common pool problem).

However, the duration of "interim" occupancy (and hence the size of benefits from investment), will now be more predictable (than under Option A), per bargain the two parties strike. This would further offset any disincentive due to benefits that LDC entrants are expected to enjoy when reclaiming their leased out rights later, after the lessees have further developed the technology in question (free rider problem).

Sharing fully in the possibly substantial interim rents, LDC rightholders may be less insistent on onerous penalties for late withdrawal by HDC users (Option A). The LDCs may also be more open to efforts to devising rights in a more transferable and exchangeable form than under 1977-type planning. Still, LDC incentives to submit excessive paper claims would be no less than under detailed planning. (The expectation of sizable rental payments might even intensify those demands). Yet the HDCs' own immediate (premature) demands for access rights may be reduced, as noted, knowing as they would of the probable future availability of unused LDC rights whenever needed.

C. Periodic Near-Term Orbit Spectrum Planning Conferences

This third option stands still further short of the 1977 type of detailed *a priori* plan. Once again, pre-engineered allotments are accepted in principle as a guarantee of latecomer access. However, we no longer assume that orbit spectrum rights can be defined in ways that render them so generally transferable as to make the leasing of unused rights practical, as under Option B.

Besides this difference from Option B, there is still another difference from detailed *a priori* planning (without leasing), namely, that the degree and timing of rights specification are left open. The main attributes of Option C, then, are (a) the convening of planning conferences every four or five years (to devise a new eight-year plan), on a routine basis, with no need for explicit administrative action by ITU members, (b) the limiting of initial allotments to near-term orbit spectrum needs, with rights limited (say) to one or two satellite lifetimes; (c) postponement of more detailed input specification until technology emerges and knowledge improves.(12)

Knowledge that access rights will be re-examined rather more frequently than the 20-year hiatuses between successive past WARCs, might help reduce all users' temptations to pad their initial claims prematurely, provided, at least, that rights are specified sequentially, at successive conferences, with increasing detail as technology and knowledge emerge.

A major disadvantage of the rigid detailed 1977-type plan is that very few bilateral trades are possible. The detailed orbit spectrum-antenna beam-time-power rights tacitly vested (say) in Chad, would only have value to Chad, and to no other nation. It follows, then, that the intrinsically multilateral character of the agreements necessary to accomodate new (or expanded old) systems, would virtually require periodic renegotation (as under Option C). The frequent planning conferences envisioned here could in principle facilitate the multilateral adjustments now required in many communications services (where bilateral trades are awkward and few at best), to move spectrum rights from lower to higher valued uses. (This is especially true in the HF, AM, and space satellite bands marked by far-flung interference patterns). Nevertheless, those multi-party transactions would be very costly unless the details were specified gradually, as just noted, in light of improved knowledge of orbit spectrum utilization.(13)

Whether or not such arrangements will reduce orbit congestion significantly (or do so without serious impairment of technological advance), depends in some measure on the extent that prior rights are "grandfathered" at each successive conference. It can at least be shown that the proliferation of orbit spectrum claims *and* the investment incentives for new technology will both be greater, the greater the degree to which spectrum users can expect their prior rights to be "grandfathered."

Hypothetically, then, at one polar bound -- "starting from scratch" at each conference -- disincentives for new investment by HDCs could be greatest, but the need for LDCs to proliferate their paper claims well in advance of their capacity to use them, least. In view of these opposing tendencies, such multilateral arrangements on orbit spectrum may be more suitably pursued through an intergovernmental consortium of owners and users, geared to creating space satellite facilities that provide domestic service for each member, though with far smaller necessary claims on orbit spectrum than if the members had acted separately. We consider several versions of such a consortium next in Option D.

D. Regional Consortia of Owners for Domestic Satellite Service

Users of common pool resources like orbit spectrum may extend their rights unilaterally or otherwise widen their effective coordination unit. In principle, if a single entity owned the whole resource, it might better recover all the benefits of setting any given utilization rate, and of making it responsive to the future value of resource output and to its effects on capital and operating costs.(14) Intergovernmental regional consortia are a possible mechanism to effect the latter.(15)

Basically, a regional LDC consortium might restrain the proliferation of domestic satellite system and hence the race for slots and frequencies. We already know, e.g., that the 104 members of Intelsat would individually claim far more orbit spectrum for domestic systems, than they collectively would if Intelsat opted to provide the domestic service itself. Likewise, a regional Latin American consortium might provide domestic broadcast and thin route service, with a fraction of the orbit spectrum that its 30-odd national members might otherwise claim.

The big question for review, however, is what the LDCs would get in return for their cooperation in economizing orbit spectrum.

OPTION D1

One scenario might be for LDCs to exchange the orbit spectrum rights they would individually lack the resources and know-how to use in the foreseeable future, for a tangible satellite-based communications service literally funded out of (a) the domestic productivity increments which a point-to-point service might subsequently generate(16), or funded by (b) those advanced nations most likely to capitalize on orbit spectrum which a consortium could release, or donated by (c) transnational corporations, in further exchange for exclusive rights to sell consortium members (i) earth terminal equipment, (ii) home receivers, or (iii) a wide range of consumer products and services via spot commercial announcements on locally produced TV programs.(17)

OPTION D2

A second scenario might be for (say) an LDC consortium simply to hire an outside concessionaire on a lowest bid basis to provide thin route and broadcast service (without awarding exclusive rights to advertise or sell products), where the initial capital funding might be (a) underwritten by a big loan guarantee via the World Bank by the U.S. or some other advanced economy likely to benefit most from the orbit spectrum released(18) but (b) ultimately paid off from productivity increments the new thin route service facilitates.

The scale ecomonies a consortium's space facility would enjoy represent a possibly decisive benefit for its LDC members, as, for advanced countries, would a consortium's capacity to internalize the negative externalities of spectrum use (and hence to reduce spectrum congestion). But the likelihood of any such consortium materializing may be impaired by the internal divisions and rivalries of members within the region. Whether such divisions must finally preclude the needed organizational initiatives is hard to predict. However, the uncertainties do underscore the need to consider still another strategy.

OPTION D3

An outside concessionaire might simply line up interested LDC clients in a region, acquiring needed orbit spectrum from them, and then building, installing, and operating the space segment on a fee-per-circuit supplied basis.(19) Here the regional grouping might be put together entirely through outside initiatives and planning, with virtually no formal organizational framework created, or agreed to, by the clients themselves. This "quasi-consortium" might provide many of a more formal consortium's advantages (scale economies for LDCs, orbit spectrum economy for HDCs), though without the alleged internal conflicts. Against this, however, must be weighed the probable opposition of LDCs due to (i) their continued dependency on Western initiatives, (ii) mistrust over the bargain finally struck on the rates they are charged vs. the orbit spectrum rents they enjoy.

All three versions of a regional consortium would operate to reduce orbit spectrum congestion insofar as LDCs could secure effective access collectively well before each could do so individually, especially via large scale utilization economies of orbit spectrum. That is, the larger coordination unit created here would act to internalize the negative externalities of unfettered orbit spectrum utilization, under a regime of first come first served.

By the same token, the incentive effects of such arrangements on investment in technological advance will depend on (a) the bargains finally struck between transnational corporation and LDCs in Option D1, (b) the long-run prospects of any concessionaire's ability to retain adequate LDC clients in Option D3 (where it exercises an organizing initiative), and in Option D2 (where it does not).(20)

E. An Intelsat Subdivision for Global Domestic Satellite Service

A fifth and final option would be for Intelsat to provide domestic service for all developing nations (running an ITU-type GLODOM)(21) or to create separate regional facilities towards that end. At present, some 20 Intelsat LDC members buy their fixed domestic service from the parent company, and another 14 appear to be interested. Furthermore, current Intelsat plans provide for higher power Intelsat V-A satellites (32 dbw), linked to lower cost ($20,000) earth terminals. The organization is said to have already spent many millions of dollars to develop such a configuration. Yet some observers see no clearly affirmative mandate today for Intelsat to provide substantial domestic service (the latter currently accounts for only 10 percent of its revenues).

Under the present charter, no Intelsat member may now establish its own system unless (a) technically compatible with Intelsat, and (b) it poses no serious threat to Intelsat revenues.(22) Yet without a really credible competitive alternative (as in Option D), would Intelsat ever venture far into the field? Some students contend that this might require a possible charter alteration subject to approval (among other groups) by Europeans unwilling to act unless guaranteed a share of procurement contracts that the U.S. may well oppose as inimical to open competitive bidding.

Only if a credible competitive alternative to Intelsat for domestic service threatened its rate of growth generally, might Europeans feel that letting it pursue that business extensively made economic sense for them too, with or without guaranteed procurement contracts. Regional consortia might constitute that kind of competitive alternative, sufficient to win European support for a formal mandate for a domestic function. This would especially be so if such regional consortia raised the prospect of subsequent transnational hook-ups.

But serious questions would still remain: Would even Intelsat's provision of domestic service induce LDC members to abandon claims on orbit spectrum for their own future systems? Or would LDCs reject continued dependency on Intelsat in view of its traditional focus on high volume traffic in major urban corridors, with heretofore low power satellites and high cost earth terminals? Might the LDCs therefore not be more likely to favor active participation in arrangements where they install their own systems (at least through a Regional Consortium, as sketched under Options D1 and D2)?

Perhaps only if LDCs ultimately perceive monetary returns on their Intelsat investment (as co-owners/users) as an acceptable way to share in orbit spectrum rents derived from the domestic service that Intelsat itself supplies them, might their own direct claims on orbit spectrum be foregone. Only then would the Intelsat subdivision operate to reduce orbit spectrum congestion. However, such a domestic service is unlikely to impair the HDCs' incentives to invest in new technology for themselves, and hence to add to orbit spectrum congestion. This is in part because "free riding" is less likely where the nations involved (as just noted) are at different stages of development, and hence have differing communications needs.

CONCLUSION

Without trying to select any "best" policy approach, our five middle range options offer starting points for identifying workable compromises between the current evolutionary management system of first come first served which Third World nations deplore, and the kind of minutely specified *a priori* planning they increasingly appear likely to impose on highly developed countries. Eventual modus operandi may conceivably combine different attributes of any or all scenarios reviewed here, or of still others.

Each scenario is considered a potential vehicle for reconciling equity with efficiency in the face of possible market failures due to common pool and free rider problems. Overall, the scenarios offer ways to narrow divergent interests of developing and developed countries. In so doing, the economic value of orbit spectrum has emerged as a potentially important source of income to facilitate economic growth of the poorest nations. Each scenario can indeed be appraised in those terms too, as well as relative to economic efficiency.

In contrast, advanced nations would stand to gain if any such allotment plan permitted them to lease unused rights from developing countries which would thereby would enjoy a share of orbit spectrum rents far earlier than otherwise. The main impediment to such leasing now lies in the minute, overspecification of orbit spectrum rights geared to provide once-and-for-all protection for all latecomers in the face of unpredictable technological change, as well as of changing rates and locations of satellite installation.

Under the kind of orbit spectrum access rights now envisioned, there would be high transactions costs both because (a) very few bilateral trades are technically possible except for long, narrow countries with extensive common borders, and (b) there is a resultant need to convene periodic, routine regional planning conferences, perhaps every four or five years, to lay out new plans (for the lifetime of the satellite equipment perhaps), starting as much as possible from scratch. The intrinsic multilateral character of the transactions would actually require an overall review of all users, with numerous parameters changed to accommodate latecomers.

Those higher transactions costs of routine multilateral re-planning must be compared with possibly higher enforcement costs of a regional consortium holding all its members' rights, or of individual nations monitoring their own rights. On the latter points, we must evaluate (a) the possible emergence of spectrum usage monitoring firms expert in detecting violations of assigned rights, and (b) the role of international mechanisms, both geared to assuage the mistrust of developing nations (given their inferior technical expertise) in assessing evidence from advanced countries.

There is in any case no question that a consortium of nations (global or regional) would need far fewer orbit spectrum rights to service its members than the latter would if each country were to install its own system separately. Whether these nations would in fact claim only "needed" rights at any space conference (and forgo still others for uncertain future use), depends largely on the concessions offered to insure such cooperation.

NOTES

[1] Third World uncertainties and fears of unwanted outcomes given their information deficiencies and greater subsequent knowledge about what they did "wrong" in prior negotiations, are analyzed in R. Cruise O'Brien and G.K. Hellener, "The Political Economy of Information in a Changing International Economic Order" (to appear in *International Organization*, Fall 1980). The authors comment on resultant desires of developing nations for simple clear-cut guarantees of predictable results, and their suspicions of Western technical information and complex administrative procedures. See especially loc. cit., at pp. 7-8, 13-14, 18-21 (pre-published mimeo, R. O'Brien, University of Sussex, U.K.).

[2] Third World perspectives on frequency spectrum and orbital access are reviewed in Academy for Educational Development, *Results and Implications of WARC/79 for Development Communications: A Report to USAID*, Feb. 1980 (Washington, D.C.), chapter 2, and ____, *WARC/79:Development Communications Strategies - A Report to USAID*, March 1979, chapter 2. More generally, see Congressional Research Service, *The World Administrative Radio Conference of 1979: U.S. Preparations and Proposals*, reprinted in *Congressional Record--Senate*, July 12, 1979, secs. IB and IIB (at S9313-9315). A. Rutkowski, "The 1979 World Administrative Radio Conference: The ITU in a Changing World," *International Lawyer*, Spring 1979, pp. 289, 293-95; Symposium on Making WARC Work, *Foreign Policy*, April 1979, especially at pp. 139-53 (papers by A. Branscomb and Curtis White). See also G. Codding, "The New Nations and ITU: Some Policy Implications for the Future," Sixth Annual Conference on Telecommunications Policy Research, Airlie, Va., April 1978, pp. 9-24, and Codding, *The U.S. and the ITU in a Changing World*, OT Special Publication 75-6, December 1975, pp. 1-13.

[3] Some such choice is at least sketched in E. Parker, "Communications Satellites for Rural Development," pp. 6-7 (paper for Eighth Annual Conference on Telecommunications Policy Research, Annapolis, Md., April 1980); ____, "Communications for Economic Development," p. 7 (paper for World Communications Conference, Annenberg School, University of Pennsylvania, Philadelphia, Pa., May 1980); R. Rice and E. Parker, "Cost and Policy Implications of Communications Satellite Systems for Rural Telecommunications in Developing Countries," pp. 36-37 (paper for Seventh Annual Conference on Telecommunications Policy Research, Skytop, Pa., April 29-May 1, 1979).

[4] The bolstering impact of restrictive OPEC price-output policies on the relative economic growth of oil-exporting developing nations has by now been documented. See *World Development Report*, 1980 (New York: Oxford University Press for World Bank, 1980), pp. 3-13. As equatorial countries, the oil-importing sub-Saharan nations (the poorest on many counts), could conceivably extract dual benefits from the orbit spectrum. They are not only potential lessors generally of access rights which some future space conference may assign to them, but also of rights with the *unique* attributes associated with equatorial territories. See, e.g., Congressional Research Service, loc. cit. note 2 above, at p. S9313 ("The technological issues (at WARC/79) include...a plan by Colombia and some other Third World equatorial countries to allocate orbital 'parking slots' for geosynchronous communications satellites and/or to establish a fourth (equatorial) ITU region--there are now three for the entire globe-- to enable these states to function like a cartel and perhaps to exploit their unique resource, the equatorial airspace needed for geosynchronous satellites...."). See also Ithiel de Sola Pool, "The Problems of WARC, *Journal of Communications*, Winter 1979, p. 189.

[5] Common pool inefficiencies are widely discussed in economic literature. See generally, H. Gordon, "The Economic Theory of a Common Property Resource," *Journal of Political Economy*, April 1954, pp. 124-42, further qualified by Scott, "The Fishery: The Objective of Sole Ownership," *Journal of Political Economy*, April 1955, pp. 116-24. The pressure for entry control and inter-user agreements is underscored in Scott, "Economics of Regulating Fisheries," in *Economic Effects of Fishery Regulation* (Rome: FAO, 1962), pp. 27-58; and in J. Crutchfield, "An Economic Evaluation of Alternative Methods of Fishery Regulation," *Journal of Law and Economics*, October 1961, pp. 131-34, 139-40. See also E. Haefele (ed.), *The Governance of Common Property Resources* (Johns Hopkins University Press, 1974). For an illuminating analysis of analogous issues in ocean resources, see R. Eckert, *The Enclosure of Ocean Resources* (Hoover Institution Press, 1979), pp. 99-108, 118-20, 244-45.

[6] On the radio spectrum resource, see H. Levin, "Externalities, Common Property Pricing and the Management of TV Broadcast Rents," in H. Trebing (ed.), *New Dimensions in Public Utility Pricing* (MSU Press, 1976), pp. 83-90, and ____, *The Invisible Resource* (Johns Hopkins University Press, 1971), pp. 26-34.

7Free rider problems are further examined in Eckert, loc. cit., pp. 241-44. More generally, see G. Stigler, *The Citizen and the State* (University of Chicago Press, 1975), pp. 107-11, 128, and T. Moore, "The Purpose of Licensing," *Journal of Law and Economics*, October 1961.

[8] The guarantor concept has been helpfully sketched in Academy for Educational Development, *WARC 79: Development Communications Strategy -- A Report to USAID*, March 1979, at pp. 29-31. See also discussion in Kalba, Bowen Associates, *WARC/79 and the Global Spectrum Problem: Final Report* (Cambridge, MA, July 27, 1979), pp. 62-65 (limited distribution for NYU Summer Institute on International Telecommunications Policy Program, June 1980).

[9] Safeguards and access criteria are reviewed in Academy for Educational Development, *WARC 79: Development Communications Strategy*, p. 31

[10] On spectrum leasing in the international field, see detailed analysis in Mathtech Inc., Economic Techniques for Spectrum Management, Dec. 29, 1979 (A Report to NTIA), especially chapters 12-13. See also C. Jackson, "The Orbit Spectrum Resource: Market Allocation of International Property," Telecommunication Policy, Sept. 1978, pp. 179-90, and more generally, President's Task Force on Communication Policy, Staff Paper No. 7, June 1969, "Use and Management of the Electromagnetic Spectrum," Pt. 2, Appendix G (TEMPO REPORT), sections 4, 7 (A Lease/Sale Market System; Spectrum Leasing for Satellites). Developing nations are also known to lease out utilization rights for purposes of developing abundant mineral reserves over which they are sovereign, but which they lack the technology and know-how to exploit independently. Under contracts with transnational corporations, the rights will normally revert to them at some point. (See sample contract between Petroleo Brasileiro S.A. and outside contractor, especially Articles 2,5,16,17, 18,19; and Supplemental Agreement of Dec. 16, 1974 between The Government of the Republic of Liberia and Bong Mining Company, especially Articles 9,11,12,14,16. Available at United Nations Center for Transnational Corporations, New York City).

[11] On developing countries' mistrust of the West's expertise and complex procedures, and its polarizing (rigidfying) effects on Third World policy proposals generally, see R. O'Brien and G. Hellener, loc. cit. note 1 above.

[12] This view of "pre-planning" has been informally discussed from time to time in responsible government circles. See, e.g., Aviation Weekly and Space Technology, May 5, 1980, pp. 74-75.

[13] The larger the number of parties to the transactions, the greater the complexity and cost of arriving at agreements on who will operate where, at what rate, and share what portion of total output. Periodic near-term planning conferences must cope with the latter problem unless leasing arrangements can be devised to obviate it (Option B). At issue, also, is any rightholder's ability to spoil the whole transaction by "holding out," and hence to "blackmail," or extort excessive concessions from, other groups of users. For if such agreements are to be reached at all, or once reached, sustained, transactions, enforcement, and exchange costs must be lower than the resultant gains.

Such issues are aptly examined in R. Coase, "The Problem of Social Cost," Journal of Law and Economics, October 1960, pp. 15-18, 26-28, 41-44; ____, "The Federal Communications Commission," Journal of Law and Economics, October 1959, pp. 29-30; H. Demsetz, "Toward a Theory of Property Rights," American Economic Review, May 1967, pp. 347-50; ____, "Exchange and Enforcement of Property Rights," Journal of Law and Economics, October 1964, p. 12. See also A. De Vany et al, "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal Economic-Engineering Study," Stanford Law Review, June 1969, pp. 1499-1561; J. Minasian, "Property Rights in Radiation: An Alternative Approach to Radio Frequency Allocation," Journal of Law and Economics, April 1975, pp. 221-72; R. Coase, W. Meckling, and J. Minasian, Problems of Radio Frequency Allocation, Rand Memo RM-3598-NASA, May 1963.

[14] On the principle of unitized resource management, see citations in note 5 above. An illuminating application of single firm ownership to internalize the negative externalities of common property usage appears in W. Baxter and L. Altree, "Legal Aspects of Airport Noise," Journal of Law and Economics, April 1972, pp. 78-82. See also H. Levin, "Externalities, Common Property Pricing.....," loc. cit. note 5 above, at pp. 99-104.

[15] See generally, Eckert, "Exploitation of Deep Ocean Minerals: Regulatory Mechanisms and United States Policy," Journal of Law and Economics, April 1974, pp. 171-74.

[16] The relative productivity of investment in point-to-point (telephone) and one-way radio broadcast service in developing countries has been assessed in A. Hardy, The Role of the Telephone in Economic Development (Stanford University Institute for Communications Research, 1980), pp. 66-114. Investment in telephones is seen as a distinctly better bet for economic growth. See also conclusions drawn by E. Parker, "Communications for Economic Development: The Satellite Example," pp. 4-5 (paper for World Communications Conference, Philadelphia, PA, May 1980).

[17] Aside from economic effects, if a broadcast infrastructure were desired as such (for cultural and educational values) an LDC could conceivably fund it by selling exclusive rights to advertisers, or to hardware companies to sell needed equipment or receivers. Such arrangements are reputed to have been proposed by Western companies on occasion, albeit without success. A well-known local U.S. analogy relates to the contract New York City eventually let to a concessionaire to build and maintain some 4000 bus stop shelters (for a ten year period). The shelters were to be built gratis, and the City to be paid 20.5% in annual royalties out of revenues earned, all in exchange for concessionaire's right to insert two panels of advertising in each shelter. See New York Times," New York Bus Shelters Case: Business, Law and Politics," May 19, 1980, pp. A1, B6; Board of Estimate of City of New York, Convenience and Safety Corporation, Proposed Form of Contract, Nov. 22, 1978. Proposed franchise has been contested by initial contract holder Bus Top Shelter, Inc. and is currently under review by a lower court in New York). A second analogy relates to the proposed requirement that future cable TV franchisees construct, again gratis, facilities for special cable channels for exclusive use by municipal agencies, educational users as well as public access groups, and additionally pay some percentage of royalties on revenues earned, in return for franchisee's exclusive rights to wire designated

communities, to charge subscriber fees, to lease channels to commercial users, etc. (On The Cable Report of the Sloan Commission on Cable Communications, McGraw-Hill Book Co., 1971, pp. 141-148). Such trade-offs have figured most recently in New York City. It has been proposed, e.g., that "free installation and free basic service" be provided by franchisees in return for rights in part to set premium charges on subscribers for delivery of special pay-cable programming. New York Times, Sept. 24, 1980, p. B1 et. seq.; Sept. 30, 1980, p. B1, et seq. On the potential franchisees' construction costs, service requirement, capital sources, and rate-setting discretion, see New York City Cable Action Plan, submitted to Department of City Planning from Arnold & Porter, Inc., Washington, D.C., Sept. 29, 1980, Vol. 1. See especially Executive Summary (pp. viii-xxx), and chapters 2(services), 3(access), 5(franchise areas and construction), 6(economic and related issues), 8(franchise agreements).

[18] The issues here is not whether telecommunications investment in developing nations is economically productive (still questioned by the world investment community). Rather is it whether the developed countries can productively use the released orbit spectrum, sufficiently to elicit loan guarantees big enough to induce potential Third World spectrum claimants to forego some of their claims. (The latter would presumably do so in return for help to launch their hypothesized consortium). Some such proposal may be somewhat more "salable" to both sides today than hitherto. See New York Times, Sept. 23, 1980, p. D1 ("Consultants to the Third World — 3 Investment Banks Join to Sell Advice"); Sept. 29, 1980, p. A1 ("Developing Nations Asking More Credit and Voice on Loans — IMF and World Bank Are Expected to Grant Moderate Concessions"); Oct. 4, 1980, p. 32 ("World Bank, IMF Gird for Bigger Role — Members Back More Lending").

[19] Though still only in a discussion stage, Hughes Communications Services, Inc. is reputed to be exploring such possibilities by adapting its first major service leasing project, LEASAT (originally conceived to supply worldwide satellite service for the U.S. Navy).

[20] Developed countries would not underinvest in satellite or HF radio systems if their technical information could be kept secret, their development costs were large, and their technology not readily replicated by LDCs. Under those conditions, the latter would have less incentive to "free ride" as just described, but more to enter into joint ventures with developed countries, or to hire them to develop LDC resources under mutually acceptable contractual agreements.

[21] The proposed Global Domestic Satellite System (GLODOM) is described in R. Butler, International Colloquium on Science, Technology and Society: Needs, Challenges and Limitations -- The Application of Telecommunications Technology to Development, Annex II.

[22] Agreement Relating to the International Telecommunications Satellite Organization ("Intelsat"), Aug. 20, 1971, Article III (Scope of Intelsat Activities).

***Strictly speaking, ITU members secure only the right to recognition (and protection) of their operations which might be subject to international interference. That is, they formally incur only non-enforceable obligations not to cause interference to the recognized services of others. Yet collectively, such obligations imply that individual nations do enjoy the right not to be interfered with. By "rights" or "vested rights" in this paper, therefore, I refer throughout to rights in this rather special sense.

INTERNATIONAL LEGAL BASES FOR ACCESS TO DOMESTIC DIGICOMMUNICATIONS SATELLITE SERVICE WITHIN THE PACIFIC BASIN

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Abstract

This paper briefly examines technological trends creating digital multibeam communications satellite systems, international legal trends promoting broader access to geostationary satellite communications and the impact of these trends upon access to domestic communications satellite service within the Pacific Basin. The paper notes significant disparities in access to satellite communications and suggests means of bringing about greater and more broadly distributed sharing of satellite-relayed bandwidth.

Geostationary communications satellites (1) provide space-based information channels by which geographically dispersed communicators can exchange messages at high capacity microwave frequencies. A new generation of digital communications ("digicommunications") satellite systems will appear in the early 1980s and are distinguishable from current analog communications satellite systems by their employment of solely digital signal transmission (2), their reliance upon the 14/12 GHz Ku microwave band (3), and their design as common carriers for organizations with large long-haul data, voice and video communications needs.

The first satellite digicommunications systems of the eighties, those with overlapping, carefully contoured fixed beams like those of Satellite Business Systems (SBS), provide high traffic networks with ample bandwidth users can access efficiently using digital signal transmission and TDMA.(4) All network nodes under the beam are interconnected by satellite broadcast. However, because these single beam satellites use neither power nor spectrum efficiently, their total available capacity will soon appear inadequate and they will eventually be replaced with contiguous and scanning multibeam satellites. The multibeam satellites, especially when designed to include separate high capacity spot beams, provide desired levels of digital service to both heavy and light system users, while conserving spectrum and maximizing ground power levels from given satellite power sources. Network nodes under multibeam satellites are interconnected by SS/TDMA. (5) Satellite constellations magnify the benefits of multibeam satellites by distributing each satellite's power over smaller regions and interconnecting regions with SS/TDMA intersatellite links. (6). All-digital satellite-based communications networks will be carved from both single and multibeam satellites. As more localities find themselves highlighted by increasingly focused beams, the digital networks will include ever broader segments of society. This paper addresses the extent to which international space law promotes the establishment of these digicommunications networks throughout the Pacific Basin.

The peoples of the Pacific Basin may currently be categorized as being at, or moving to, one of three levels of access to the practical benefits of domestic satellite communications. Countries with dedicated communications satellite systems -- the Soviet Union, Canada, the United States and Indonesia -- enjoy the highest level of access. (7) Dedicated systems, engineered to deliver an optimal level of service to the territories they serve, can allow use of simplified receiving equipment so that even isolated, low-volume traffic streams can share in geostationary satellite communications.

Countries leasing spare transponder capacity from another's satellite for domestic telecommunications also enjoy some access to the benefits of satellite communications. These transponder lessees -- Australia, Chile, Colombia, Malaysia, Peru and the Phillipines -- must satisfy themselves with a level of access to geostationary satellite communications which is far below that provided by dedicated systems. The lessor, INTELSAT (except for the Phillipines, which leases from Indonesia), generally provides one transponder, on a pre-emptible basis, for around a million dollars per year. (8) The diffuse INTELSAT beam necessitates costly ground stations, which, in turn, sharply circumscribe public access to the benefits of domestic satellite communications. Finally, there are many countries with no access to the benefits of domestic satellite communications.

The realities of three clearly discernable levels of access to the broad, easily interconnected and well-distributed bandwidth of satellite communications should be checked against the requirements of applicable international legal regimes. It is through these legal regimes that the world has stated the standards of access which should prevail.

The basic principles governing utilization of the geostationary orbit were agreed-upon in 1967 in the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (" Outer Space Treaty ")(9). Two of the most important principles are that: (i) the geostationary orbit shall be utilized "for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development . . . ," and (ii) the geostationary orbit "shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law . . . ." (10) The key source of international law with regards to satellite and all other forms of radio communications has long been the International Telecommunications Union (ITU).

An international consensus on the basic legal norms of radio communications has existed since States agreed to improve turn-of-the-century maritime radio service through concerted action and universal rules. This consensus matured following each World War, so that by 1947, the United States could seriously propose to an actually not-yet-ready world that the radio frequency spectrum be "engineered," with services allocated to their physically optimal bands and frequencies assigned to countries in accordance with their changing needs. Largely because of the inability of an international consensus to coalesce on the truly advanced issue of spectrum engineering, ad-hoc international frequency management developed along with elaborate procedures for determining preferential rights to frequencies involved in harmful interference disputes. It was into this mature regulatory environment that satellite communications was born.

From the very beginning of commercial satellite communications, the international community was obligated to define space services, restrict these services to appropriate bands, and undertake special coordination efforts to minimize interference between the new space services and their terrestrial gigahertz-band cotenants. As space service ITU frequency registration procedures institutionalized the unchallenged competence of the international community in satellite communiations, the complexion of this community was being reshaped by the influx of fresh perspectives from new sovereignties. The contemporary international community is acclimated to its new complexion, appreciative of its unchallenged authority and accustomed to satellite technology. Never before has the international community, operating as the ITU, been so politically and jurisdictionally capable of regulating telecommunications. Power invites its own use; one must expect international regulation of satellite communications to continue expanding until consensus is clearly lost and power withdrawn.

ITU influence already permeates satellite system planning and development, especially in the Ku band frequencies employed by the new generation of digicommunications satellite systems. All planned Ku band space service systems must forward specified system data to the IFRB (International Frequency Registration Board) of the ITU for worldwide publication. Those responsible for the new satellite system are then obligated to engage in discussions and document exchange with all those who may suffer harmful interference as a result of the new system. Systems which may cause each other harmful interference must "coordinate" their technical parameters until all potential interference is within acceptable limits. One reward for engaging in these activities is registration of one's coordinated satellite frequency/orbit parameters in the IFRB's Master Register. The registration bestows "international recognition" and the consequent right to demand coordination from any and all subsequently deployed satellite systems capable of causing harmful interference.

The nature of future ITU regulation of digicommunications satellite service will, in large part, depend on the meaning eventually given to WARC-79 Resolution BP, the recently articulated ITU objective to convene a 1984 Space Conference to "guarantee in practice for all countries equitable access to the geostationary-satellite orbit and the frequency bands allocated to space services . . ." (11) At minimum, by guaranteeing equitable access in practice, the world will probably agree they mean to insure to all countries the right, exercisable upon need, to be expeditiously provided with an interference-free frequency and associated orbital position from which a fixed or broadcast-satellite service can operate. At most, guaranteed access will mean the *a priori* assignment of frequencies and associated orbital positions for all non-scientific space services and in all currently utilizable bands. In other words, the world has agreed that every country is entitled to preferential international recognition with respect to at least some frequency/orbital position combinations -- this much guarantees in practice to all countries equitable access to space service frequencies and to associated orbital positions. But world consensus is still evolving as to at what point in time this preferential international recognition shifts from a tacit to an active state.

A posteriori orbit/frequency assignment *methods, under the* new "guarantee in practice" regime, would activate preferential international recognition upon an administration's need for the same. *A priori* orbit/frequency assignment methods *activate preferential* international recognition in advance of the space service needs of administrations. Eventual world consensus as to at what point in time and for which space service bands tacit preferential international recognition should give way to an active exercise of the right, will be determined, in large part, by the nature of, and confidence in, *a posteriori* *procedures for activating preferential* international recognition. Indeed, resolves 3.4 of Resolution BP requires the 1984 Space Conference to "consider other (non-*a priori*) approaches that could meet the *objective of* resolves 1," (12) and American WARC-79 observer Rutkowski relayed that Indian delegate Srirangan, the driving force behind Resolution BP and the coordinator of Non-Aligned Movement positions on these issues, "urged that the period between the entry into force of the WARC-79 Final Acts and the 1984 Space Conference be used to experiment with alternate *a posteriori* rights vesting mechanisms." "Unfortunately," continued Rutkowski, India's suggestion "seemed to be rejected by the leading developed country spokesman," and the "lack of any meaningful experimentation with alternate *a posteriori* procedures will probably tend to increase the resolve of developing countries to adopt an *a priori* mechanism at the 1984 Space Conference."(13)

It may be concluded that the legal regime governing geostationary satellite communications is in flux. There is movement from a regime which emphasizes freedom of national access to the geostationary resource to one which emphasizes universality of such access. This also entails movement from a regime which weakly asked that some fraction of the geostationary resource -- without specifying how much -- be used "for the benefit and in the interests of all countries . . . ,"(14) to a regime which "guarantee(s) in practice for all countries equitable access to the geostationary-satellite orbit and the frequency bands allocated to space services . . . ." (15)

Where does this changing of the legal guard leave the peoples of the Pacific Basin? By abandoning unfettered freedom of national access to nominal orbital positions, (16) those States capable of capitalizing on this freedom, those with dedicated systems on orbit or on order, may lose some access. This conclusion is most problematic however, as even under a rigid *a priori* nation-by-nation frequency/orbital slot assignment plan, administrations are assigned channels according to (above a low floor) their demonstrated and prospective demand for satellite communications. (17) Those Pacific Basin countries currently enjoying top-level access to domestic satellite communications should weather the change of legal regimes with no loss of access, although maintenance or expansion of existing access levels may involve increased coordination costs.

Any imposition of *a priori* nominal orbital position assignment plans by the evolving legal regime will benefit only one class of user -- those States which are preparing to launch satellite systems into segments of the geostationary arc already crowded with the satellite systems of others. This is because *a priori* plans accord "preferential international recognition" to the administration operating in accordance with the assignment plan, whenever they orbit their system. Under the traditional legal regime, "preferential international recognition" was essentially bestowed upon the first administration to operate a space station at a given nominal orbital position.

Neither the traditional nor the ascendant legal regimes yet provide realizable access to the benefits of domestic satellite communications for Pacific Basin countries not able to support a dedicated communications satellite. While Resolution BP of WARC-79 resolves "to guarantee in practice for all countries equitable access to the geostationary-satellite orbit . . . ," its operative provisions are basically addressed only to implementing space service assignment plans -- a scheme of benefit only to the few administrations preparing to orbit dedicated systems. However, dedicated communications satellite systems are generally only viable options for States with large geographically dispersed populations. Domestic satellite communications will come to most countries only through cooperative regional arrangements. Regional systems are highly desirable because they bring "custom-engineered" satellite channels to participating countries, and in doing so with only one satellite system per regional arrangement, aid significantly in conserving the geostationary arc. Because the benefits of geostationary satellite communications are effectively shared by smaller countries only through regional arrangements, the guaranteed universal access obligations of the ascendant legal regime appear to require concerted international efforts towards the creation of new regional communications satellite systems. The suggested vehicle for these regional systems are Satellite Communications Utilities.

Satellite Communications Utilities could be formed at special Regional ITU Conferences where developed nations could provide technical input as to optimal system configurations and developing countries could provide political input as to desired groupings of countries. In Region 2, for example, the communications needs of the United States, Canada, Mexico and Brazil are each substantial and justify dedicated communications satellite systems. The smaller countries, however, need to share satellite capacity in order to obtain realizable benefits. These countries could form utilities to render regional satellite communications service. An Andean utility and a Caribbean utility are two possible systems.

It clearly gives the smaller Pacific Basin country no real "access" to reserve her chimeric orbital slots and channel assignments. What she needs is service, not vacant space. The Satellite Communications Utilities will provide this service in an optimal manner, while also allowing direct broadband links among neighboring countries. The lack of dependable telecommunications links between many neighboring developing countries, a fact not generally appreciated in the West, is one of the major reasons Third World countries have called for a New World Information Order. (18)

While it is beyond the scope of this paper to discuss the financing of these Satellite Communications Utilities, it will be noted that strong arguments can be made for international developmental financing (e.g. World Bank, U.N.D.P.), multilateral developmental financing (e.g. pooled resources of developed countries in each ITU Region), or Third World financing (pooled resources of countries comprising the utility. Another possibility, available from Hughes Communications Services, is for the utility to lease the satellite service it requires and to make payments from the utility's operating revenues. (19)

Practical measures to be taken toward establishing Satellite Communications Utilities include amending the ITU Convention at the 1982 Plenipotentiary Conference in Nairobi to acknowledge the urgent responsibility of all administrations to contribute to the development of regional communications satellite systems, to set dates for organizational conferences, and to greatly increase ITU telecommunications development aid The ITU has jurisdictional authority to help create regional communications satellite systems because (i) they encourage efficient and equitable access to the geostationary orbit and associated space service frequencies, and (ii) they minimize harmful interference problems by collapsing the frequency/orbital position assignments of several willing countries into a single configuration. (20)

While great disparities in access to domestic geostationary satellite communications currently exist, significant, if not breathtaking progress has also been made in distributing space-relayed bandwidth throughout the Pacific Basin. The pace of this bandwidth generation and distribution is certain to accelerate as technology improves satellite performance and as an evolving legal regime promotes universal access to geostationary satellite communications. With continued progress along these lines, it will not be too long before access to domestic satellite communications is a birthright of all Pacific Basin peoples and a hallmark of modern Pacific Basin life.

Notes

(1) The international legal definition for a geostationary satellite is: "a satellite, the circular orbit of which lies in the plane of the Earth's equator and which turns about the polar axis of the Earth in the same direction and with the same period as those of the Earth's rotation." Final Acts of the World Administrative Radio Conference for Space Telecommunications 47 (1971). The "geostationary orbit" is the "orbit on which a satellite should be placed to be a geostationary satellite." Id. But space law and technology expert James Gehrig has observed that because satellites are subject to perturbing forces few, if any, geosynchronous satellites can practically meet the very technically precise international legal definition. Gehrig. *Geostationary Orbit -- Technology and Law*, Proceedings of the Nineteenth Colloquium on the Law of Outer Space 267 n. 4 (1977). Hence as a matter of common acceptance, geosynchronous satellites in orbits with small inclinations to the plane of the equator, nor more than 5 degrees, are still considered geostationary satellites. Id.

(2) Employment of digital signal transmission greatly facilitates dynamic allocation of satellite capacity between dispersed users (through time-division multiple accessing), increases communications capacity and decreases the cost of teleprocessing and other applications of computer-communications. Bargellini, Commercial U.S. Satellites, IEEEE Spectrum, Oct. 1979 at 37.

(3) Higher 14/12 GHz Ku band frequencies will bring ground stations to users' premises in urban centers -- a move which could not be made with traditional lower frequency 6/4 GHz C band satellite service because of interference with the terrestrial C band microwave links blanketing all high traffic areas -- and have the further advantages of (i) narrower beam width and hence room for more of these satellites in geostationary orbit without interference, (ii) a more directional beam from an antenna of a given size than that obtainable at lower frequencies and hence more opportunity to reuse a frequency in multiple highly directed beams, (iii) higher antenna gain than that obtainable at lower frequencies, thus increasing effective satellite power and reducing ground station size and cost, and (iv) less need to impose harsh limits on satellite radiated power, as exist at 4 GHz downlinks, to minimize interference with terrestrial microwave distribution systems. J. Martin, Communications Satellite Systems 136-47 (1978)

(4) Time Division Multiple Access (TDMA) allocates channel capacity by giving each of many ground stations sequential, dynamically variable opportunities to transmit a sub-millisecond "burst" of around a thousand bits approximately once every thousandth of a second.

(5) With SS/TDMA a matrix switch in the satellite rapidly, sequentially and in nanosecond-level synchronization with ground stations connects the receiver outputs associated with each beam or group of beams to the transmitter inputs associated with each other beam or group of beams. In well under a thousandth of a second, every ground station should have had at least one opportunity to transmit a burst of data into every one of the satellite's downlink beams. Ramastry et al, Advanced Westar SS/TDMA System, Digital Satellite Communications 39 (1978).

(6) The SS/TDMA scheme described in note 5 would be modified to sequentially give each ground station an opportunity to route a burst into one or more inter-satellite links in addition to the split-second opportunities given for routing bursts into each downlink beam of the ground station's own satellite. Burgess & Schmidt, Satellite Constellations Using Multiple-Beam Satellites With Onboard-Switched TDMA, *Satellite Communications: Future Systems* 468 (Jarett, ed. 1976).

(7) Japan, Australia and China will join this group within the next few years.

(8) Australia recently received permission to lease two transponders. Malaysia and Peru lease one transponder each. Colombia and Chile each lease a half transponder.

(9) Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, *opened for signature* Jan. 27, 1967, T.I.A.S. 6347,

610 U.N.T.S. 205 (hereinafter cited as Outer Space Treaty).

(10) Id. art. I

(11) Final Acts, World Administrative Radio Conference (Geneva 1979) Res. BP

(12) Id.

(13) Rutkowski, Six Ad-Hoc Two: The Third World Speaks Its Mind, Satellite Communications, March 1980 at 27.

(14) Outer Space Treaty, art. I, note 9 supra.

(15) Final Acts, World Administrative Radio Conference (Geneva 1979) Res. BP.

(16) Nominal orbital position is formally defined as "the longitude of a position in the geostationary satellite orbit associated with a frequency assignment to a space station in a space radiocommunication service." Final Acts, World Administrative Radio Conference for Broadcasting - Satellite Service in the Frequency Bands 11.7 - 12.2 GHz in Regions 2 & 3 and 11.7 - 12.5 GHz in Region 1 (Geneva, 1977) Annex 8. In essence, "the indication of this nominal orbital position means that the use of this part of an orbit for a transmitter is compatible with an operation of the system free of interference to or from other users." Butler, World Administrative Radio Conference for Planning Broadcasting-Satellite Service, 5 J. Space L. 93, 98 (1977).

(17) Mili, World Administrative Radio Conference for the Planning of the Broadcasting-Satellite Service in Frequency Bands 11.7 - 12.2 GHz (In Regions 2 and 3) and 11.7 - 12.5 GHz (In Region 1), Proceedings of the Twentieth Colloquium on the Law of Outer Space 346 (1978); See also clear description of broadcasting-satellite service plan in Av. Wk. & Space Tech., Sept. 10, 1979 at 75.

(18) See, J. d'Arcy, The Right to Communicate (International Commission for the Study of Communication Problems, Doc. No. 36, 1979); M. Masmoudi, The New World Information Order (International Commission for the Study of Communication Problems, Doc. No. 31, 1978).

(19) A. Wheelon, The Economics of Telecommunications in the Century of the Satellite (Paper delivered at World Telecommunications Forum, Geneva, 1979).

(20) International Telecommunication Convention (Malaga-Torremolinos, 1973) arts. 4, 33 T.I.A.S. No. 8572 (entered into force for the United States April 7, 1976).

Policy Outcomes of WARC '79:
Their Impact on Developing Economies

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Abstract

Decisions taken at WARC '79 and its follow-up conferences will have a significant impact on the economic development of Third World countries. This paper examines the claims of developing countries on sharing the electromagnetic spectrum and orbital space and analyses the negotiations at WARC '79 in the context of policy and technology options for developing countries. Specific WARC outcomes have been closely scrutinized in the light of ITU's role for future global communication policies.

1. INTRODUCTION

The difficulties of designing an international policy or a world order acceptable to countries at diverse levels of growth have been experienced over the years by United Nations agencies and the various fora convened by them and by other academic and non-governmental organizations. The World Administrative Radio Conference (WARC) held in 1979 drew both the developed and developing countries into the vortex of decision making which will have an impact on the lives of their inhabitants at least till the turn of the century. Results flowing from WARC '79 are likely to determine the degree and pattern of change in the existing asymmetrical interdependence within the emerging paradigm of a world political economy. The International Telecommunications Union (ITU), UNESCO and the UN Development Program (UNDP) have been operating within the constraints of a complex web of regulations and relationships that have been challenged by the Third World. It is no longer possible to placate such claims with an ideology of developmentalism which has hidden past failures. Many Newly Industrializing Countries (NICs) are impatient to leapfrog into the information age. They are eager to transform the epiphenomenal World Order into action plans here and now.

A conference report of the U.S. National Commission for UNESCO (1980) asserts that global communications are in ferment. Within the next nine years, nineteen international conferences will allocate the use of the world's electromagnetic spectrum. Decisions taken at WARC '79 and its follow-up conferences will affect the lives of people in all parts of the globe and will regulate the flows of information and commerce. This is true because communication technologies are at the leading edge of international socioeconomic and scientific developments.

2. HISTORICAL PERSPECTIVE OF THIRD WORLD CLAIMS AT WARC '79

The world economy today is not essentially regulated by the law of the market. To the extent that the market operates, it favors technologically developed nations. This planetary bargain is in danger of becoming a zero sum game unless the assumptions underlying the Third World claims are understood in their historical perspective. First of all, Third World countries do not form a single homogenous group, but have a common interest in developing their economies and providing an improved physical quality of life index for their majority of poor citizens. Decision makers in these countries are convinced of the intrinsic linkages between low cost, progressive communication systems and accelerated economic development. However the Non-Aligned movement to which these countries belong, pledged at a conference in Cocoyoc (Mexico) in 1976 to promote a strategy of Self-Reliant Development. This propelled their demands at WARC '79 towards those forms of spectrum and orbital management which would foster self-generating growth and technology in telecommunications. Since much of the Third World is located in tropical regions having heavy and unusual rainfall, they need technology suitable for communication systems that are cost-efficent in such a geographical setting (See Nolan Bowie, 1980).

As far back as the 1959 WARC, developing countries had challenged "squatters' rights" to the use of the frequency spectrum. While the spectrum and orbital resources are not presently endangered by limits to growth, the developing countries not only want a fairer division of this resource, but as Anne Branscomb pointed out (1979) they want help in developing the technological skills and economic strength to take advantage of the latest communication gadgetry.

In 1979 the United Nations Conference on Trade and Development (UNCTAD V) met at Manila and focused on several issues pertaining to a New International Economic Order, but the meeting did not bring any tangible benefits to the Third World's interests. The Summit Meeting of Non-Aligned countries held the same year at Havana discussed the common stand, which the Group of 77 (now 119 countries) would take at WARC '79 for planning the uses of the spectrum and for orbital space allocation. The Asian Regional Meeting on Communication Policies had also met at Kuala Lumpur in 1979 and supported balanced communication flows and proposals to achieve productive transfer of appropriate communication technology.

Some of the developing countries had prepared specific proposals to be discussed at WARC '79. Papua New Guinea had filed its proposals in January 1979, the Republic of Uganda in March, followed by Egypt and India in April. Since the ITU was responsible for allotment of radio channels and bands for broadcasting satellites, it was approached for all proposed changes in the existing regulations and system of vesting rights. In May 1979 the telecommunication administrators of Non-Aligned countries met at Yaounde and prepared a report for WARC. One of the significant outcomes of this meeting was a resolution calling for a future satellite planning conference. The People's Republic of China introduced a similar resolution on satellite planning when the WARC meetings began. Therefore, the criticism that Third World countries approached WARC with inadequate technical preparation does not stand scrutiny, nor the charge that all they were interested in was rhetoric and polemics. They had already expressed a desire to operate in the $12GH_z$ band for broadcasting satellites and were determined to get from the Conference a just apportionment of the radio spectrum and the geostationary orbit.

The approach to WARC '79 had been based on polarized assumptions on the part of both the First and Third World countries, which led to mounting apprehensions regarding WARC outcomes. While the U.S. had made elaborate and extensive preparations with considerable research for WARC negotiations, it had not offered similar assistance to smaller developing countries that lacked the technical and administrative expertise. Industrialized countries took it for granted that WARC '79 will turn into another UNESCO general meeting at which rhetoric overrides concrete proposals. This assumption could have been applied to the U.S. proposal to increase the number of frequencies available for shortwave for the use of Voice of America, Radio Liberty and Radio Free Europe. Such a proposition could hardly be justified as apolitical (See Broadcasting '79).

On the other hand the developing countries assumed that the First World owns 90% of the spectrum. The assumption is incorrect, as Rutkowski argues (1980) the majority of radio station emissions are confined to terrestrial boundaries and do no infringe on international rights. Another assumption that heightened tensions was that WARC should be a purely technical conference, but it brought together all the member countries of the ITU for discussing policy issues emerging from the regulation of international radio communication and had many non-technical dimensions. In fact the issues that were contentious were the non-technical aspects of telecommunications. For instance, the demand by equatorial countries and other LDCs to have planned reservations for orbital slots and to charge users' fees for the current occupation of such slots was a political issue linked with sovereignty over territorial orbits similar to the sovereignty of the economic zone within territorial waters. This political issue had to be debated within the framework of one-country one-vote, which gave collective bargaining strength to the Third World members of the ITU.

Countries of Region I and II operate fixed service satellites on a "first-come, first-served" basis and assume that demands for equal access to orbital space would lead to an inefficient use of the resource and freeze technology. In contravention to NWIO negotiations, these industrialized countries operate on the assumption that "a priori" planning services are unnecessary, since equal rights have to be matched by the ability to use those rights. First World negotiators attempted to further stonewall their own positions by the argument that LDCs underfinance their communication sectors. At the Intergovernmental Planning Conference on Communication Development held in Washington, D.C. in November 1979, it was agreed that only 0.183% of grants and loans to LDCs gets invested in communication projects and that 0.5% of UNDP financing was allocated to the communication sector. UNESCO's Funds-in-Trust program makes a deliberate attempt to find funding for the communication sector. This stance on the part of the First World prior to WARC '79 created an adversary situation.

On the other hand the developing countries view transnational communication corporations as symbols of economic exploitation and assume that they operate as the cutting edge of a capitalist world economy. Market shares of world telecommunication equipment are monopolized by corporations like Western Union, Siemans, GTE, Ericsson, Nipon Electric and Philips of Holland. Computer technology is dominated by IBM, Control Data, and Honeywell to name a few. Remote sensing satellites are so far the domain of the U.S.A. and the U.S.S.R. and are looked upon as "spies in the sky." Direct broadcast satellites are demanded by LDCs for linking remote areas within their boundaries, but their programming is suspect for its potential to generate consumerism which poorer countries cannot afford. These fears were voiced at WARC '79.

The Third World further assumes that the ITU is a kind of old boy's club, dominated by developed countries. Its structure needs to be changed because of the increased membership of LDCs after WARC '59. Exclusion of the Second World from assisting international aid flows and technology transfer is resented by developing countries, because such exclusion affords communist countries a pretext for non-involvement in LDC development. The Brandt Commission reinforced this view (1979) by criticizing the exclusion of the Second World from the IMF and the World Bank.

While the First World reassured developing countries that the HF band is not saturated, and while the ITU's International Frequency Registration Board (IFRB) declares it has never denied a request for frequency allotment, developing country apprehensions were strongly articulated at the Havana Summit prior to WARC '79.

3. THE IMPACT OF WARC '79 ON NORTH-SOUTH RELATIONSHIPS

Held in Geneva for ten weeks in 1979, WARC was attended by 2,000 delegates from 142 countries and cost the world economy $70,000 per hour covering six spoken and three written languages. Dr. Wilson Dizard, the executive director of the U.S. delegation described the WARC '79 as "an electronics superbowl" (PTC '80). Sensitivity to the role of communications as a catalyst for development and for an improved world order was indicated by both developed and developing countries. Ideology did not, as a rule, override self-interest at Geneva.

Awareness that the next decade in spectrum management will be critical for developing countries was highlighted at the WARC deliberations. In economic terms the radio frequency spectrum and its cost-effective use provides the medium upon which electronic communication equipment for transmission is dependent. Management of the usable portion of the spectrum gives direct benefits to increased productivity of the industrial, agricultural and services sectors and generates capital investment in electronic equipment. Indirectly it would help developing countries increase their knowledge of the propagation characteristics of the spectrum, particularly above 10GH$_z$, and help devise new modes of radio communication.

The significance of this conference to the North-South debate became apparent as positions hardened on how to combine economic efficiency with global equity. While the Third World could exercise its majority vote, industrialized countries knew that LDCs lacked the resources to put up satellites. Therefore, conceding orbital space would not have involved any interference in operations in the near future. The adversary situation was sought to be resolved by bridging the credibility gap. The need for technical and financial assistance for development support communications was recognized, but the concrete offers of assistance hardly appear adequate. USAID has allocated a total of $54 million over six years, of which $24 million will be set aside for satellite development. The cost of satellite technology cannot be even partially met from this assistance for a simple satellite to be launched into geostationary orbit.

In terms of winners and losers in the debate, the battle at WARC moved to communications hardware, unlike at UNESCO meetings where the focus is on balanced news flows. Procedural disagreement at the start of the Conference centered on the selection of a chairman who met the approval of Third World countries and finally led to the election of Mr. Severini of Argentina. The status quo position taken by the First World, however, prevented any "global rewrite" of the regulations, but generated consensus on incremental changes.

Major issues which would have a significant impact on the future communications of LDCs were relegated to postponed meetings. Perhaps this was fortuitous for developing countries inasmuch as decision making would not take place under pressure of conference conditions. Three world and six regional conferences have been approved involving compromise over a wide range of issues. Adjustments extending into the 1990s were called for in the HF bands for fixed services by developing countries and for maritime services. The First World resorted to the procedure of reservations whenever its special interests were threatened, whereas the Third World was eager to derive optimal use of scarce resources from the most sophisticated technology like multi-access satellites, platforms in space and satellite clusters. Postponement of the planning conferences for HF and space services gives time to the Third World to observe how far the crowding of the geostationary orbit in Region II will result in congestion and how such a situation will be remedied. Meanwhile several resolutions were passed at WARC to give developing countries increased assistance in maritime telecommunications, and national propagation studies for tropical area radio communications.

At the Conference the issue of vesting rights was decided in favor of developing countries in case of dispute, which decision will have a marked impact on improving North-South relations. In fact Rutkowski (1980) describes it as an international analog of domestic affirmative action programs. At the same time it creates an international public interest standard which would help the First World for marketing its communication systems and simultaneously meeting the needs of developing countries.

It became clear at the deliberations that the developing countries were fully in control of a united front for their demands. Specifically this came to the fore when the Third World spoke its mind as reported by Rutkowski (Satellite

Communication 1980) in a group meeting entitled Six Ad-Hoc Two. The resolution for a space services planning conference in 1984 was sponsored and supported by developing country delegates and carried through in the teeth of opposition from some advanced countries. Resolution BP of the Conference declared that a special WARC be convened no later than 1984 "to guarantee in practice for all countries equitable access to the geostationary satellite orbit and the frequency bands allocated to space services."

4. WARC OUTCOMES AFFECTING THE THIRD WORLD

Less developed countries will find their economies influenced by the following results from WARC '79:

4.1 FIXED SATELLITE SERVICE

One of the WARC outcomes likely to impact the course of a new world order is the allocation of more spectrum for fixed satellite service. For the first time, fixed service allocations were provided for feeder link frequencies to broadcasting satellites. In the bands below $20GH_z$ an increase of about $1.1GH_z$ was allotted. The demand for frequencies below $10GH_z$ was sharply contested at the conference. Developing countries advocated "a priori" planning for assigning frequency and orbital position by country, but this was resisted by the major space powers. Developing countries emphasized that if "a priori" rights are to be vested, there must be a justification without which such rights can be abused. On the other hand the space powers who already own vested rights believe that "a priori" planning would freeze technology and lead to an inefficient use of orbital resources. The Third World finds that "a posteriori" vesting of rights involves waste of financial and manpower resources in maintaining costly domestic and international administrations for operating such a system.

Therefore, a conference to plan the use of the geostationary orbit will be convened in 1984 and will take into account the claim by equatorial countries over portions of the orbit above their territories. The conference will be held in two parts. The first will establish principles and technical parameters and criteria for planning. The second conference will be held 12-18 months later to implement these decisions. This is one of the three major conferences that will affect Third World development, the other two being the conference on HF broadcasting and the Plenipotentiary.

This outcome was a major gain for LDCs inasmuch as First World resistance to "a priori" planning was modified. The economics of this outcome concerns the affordability of satellite technology in terms of opportunity costs for those countries that have pressing needs of poverty alleviation. Is it justifiable to spend scare resources on acquiring a technology that may lead to technical and cultural dependence?

However, evidence indicates that the next decade will usher in a new era of low cost earth stations for wider distribution of information to remote areas. Satellite fixed services are insensitive to distance. Developing countries have less investment in existing technology which gives them relative freedom to invest in newer satellite technology. Some of the smallest nations in the Pacific are able to get instant networks through the interactive satellite system that operates from the University of Hawaii under the PEACESAT program. The New York Times reported on December 11, 1979 that two doctors from the Center for Disease Control in Atlanta hold a monthly telephone conference via satellite with doctors in Micronesia, free of cost, because NASA makes the time available on its own satellite network for six receiving stations in the Pacific Islands. The benefits flowing to Indonesia and Malaysia from Palapa and the ancticipated benefits to India from INSAT One, all reinforce the trend of growing demand for satellite communication from the Third World.

A further impact of WARC's decision to allocate more spectrum for fixed satellite services is to provide for the flow of economic benefits through demand specific technology. For instance the Hughes Syncom IV is planned to provide 48 transponders which can be leased at low cost to developing countries. Wheelon (1979) cites the economies from leverage of specialization that would emerge if LDCs leased these transponders and custom built their own communication systems. So far INTELSAT operations in three oceans provide international communication for developing countries. With the emergence of domestic satellites it may become possible for World Bank financing to encourage leasing of transponders for domestic services and thereby accelerate the transfer of satellite technology which would tie in with the Bank's basic needs strategy.

4.2 HF BROADCASTING

In principle the conference allotted 60% of more spectrum in the major bands 9, 11, 15, 17 and $21MH_z$ for broadcasting. But their actual equitable use will not take effect until the special WARC for HF frequency meets in 1984. HF radio is of great socioeconomic importance to certain developing countries. They need point-to-point communication, but microwave systems are not cost-efficient for them in covering large territories with sparse population. The U.S. proposed an expansion in the six and seven MH_z bands for fixed service. In fact, at one point during the conference Algiers proposed that 70% of the lower shortwave frequencies be given over to LDCs, but the proposal did not receive the required support. The U.S. then put in a reservation along with the U.K. to its right to use the 6 and 7 MH_z bands until a decision is taken at the 1984 conference.

The conference in 1984 will be entirely devoted to planning worldwide shortwave broadcasting. At present the use of the HF band is not planned. Users notify the IFRB on the frequency they wish to use, except for users of aeronautical and maritime mobile services. This existing pattern has resulted in confusion and overcrowding of the band and needs to be changed. The significance of this conference for developing countries is reinforced by the resolution at the Yaounde pre-WARC meeting which urged rich countries not to clog up the HF bands because they can afford to use satellites, cable TV and fiber optics. Howkins (1979) maintains that many developing countries in Africa want to start their own international broadcasting services and members of the Asia Pacific Broadcasting Union want to switch fixed allocations for the same purpose. The economic stakes are high for the developing world because it cannot afford new technology that will make further bands accessible.

Economic factors determined the fate of using single sideband for broadcasting at WARC 1979. This proposal was set aside because First World countries are not ready to incur the high cost of replacing receivers. In the existing system, much of the radio spectrum is gobbled up by powerful transmissions, by television companies and by the non-sharing of channels. This pattern is a legacy of the past when the spectrum was viewed as an infinite and free resource. Now that telecommunication has proved its power and potential for development, there emerges the need to conserve the resource by eliminating waste. Such a technology exists in the form of single sideband broadcasting and would be of immediate consequence to developing countries for two-way development support communication. But opposition comes from those industrial countries whose large corporations have sunk investment into existing equipment. The obstacle to the use of single sideband technology is the need for more sophisticated receivers that can generate their own carrier signals. New Zealand adopted this technology after the special WARC held in 1977. The use of single sideband for cost-efficient use of the spectrum may become the next plank in the claims of the south at a future WARC, because new microelectronic technology will enable the costs of special receiver sets to decline and lead to further economies of the leverage of specialization.

4.3 REMOTE SENSING SATELLITES

Within the ITU the International Radio Consultative Committee is responsible for providing a wide range of studies concerning the performance and interface of space and terrestrial systems and their utilization of the electromagnetic spectrum (See Richard Kirby, 1980). WARC '79 charged CCIR to prepare the technical data base for the Space WARC in 1984. Assignments for geostationary orbital slots will then deal with developing country objections to "squatters' rights."

CCIR has also been assigned special studies for exploring new digital techniques for spectrum use, for studies of single sideband for broadcasting, integrated and automated UHF land and maritime mobile communication and radio wave propagation in tropical regions. A special resolution calls for studies in rural communication which will be valuable to Third World development planners. All these studies will strengthen the role of the ITU in enabling its members to participate in the technology revolution and providing it with the required flexibility.

5. CONCLUSION

The ITU has been described as a "creaking relic of the telegraph age" (The Economist) but the fact remains that WARC '79 has dragged ITU into the 21st century with its resolutions and future conferences that will impact directly on world communications. The 1982 Plenipotentiary Conference will attempt to evolve structural changes in the ITU to better assist developing countries. Problems of developing countries created a new awareness, but much greater effort is required to herald their entry into the information age. The UNDP will be the source of financing research and technical cooperation and for paving the way for LDCs to reap the benefits of changing technology. But the giants in the communication industry, like the Bell system, AT & T, RCA and Western Union are the major vendors of new technology along with communication industries of Japan and Europe. They need to restructure their costs and prices in order to make low cost options available for developing countries.

So far, international common carriers have exercised an oligopoly over the use of the 4 to 6 GH$_z$ band, which is crowded both in its space and terrestrial utilization. Without optimizing the use of this resource they have restricted entry to newcomers. Bands higher than these are too costly for developing countries to use. They are opting for the 2.5 GH$_z$ band. India wants it for INSAT educational broadcasts and ARABSAT for its domestic communications. CCIR will have to study the payoffs arising from the use of this band vis-a-vis its operational costs. Post-WARC policies will have to extend to the flow of equipment and skills for utilizing the 2.5 GH$_z$ and HF frequencies. Tariff regulations will have to be eased to facilitate the flows of hardware and the systems that accompany them from developed to developing countries. This will depend on the priority which Third World governments assign to investment in innovative systems.

Already at TELECOM '79 (held concomitantly with WARC '79) manufacturers from industrialized nations exhibited sophisticated electronic equipment and launched a major assault on the world telecommunications market. At the same exhibit LDCs displayed their current level of technology and their future requirements. As world investment in telecommunication has grown to $4.5 billion in 1979, banks and financial institutions are eager to stake their investments in this industry.

WARC '79 has pointed in the direction of communication becoming one of the major contributors to social transformation and to the economic development of the periphery. If participatory planning at the grassroots level is to become a reality, people at the periphery need information; they need to communicate with each other, with metropolitan markets, banks and government institutions. Without doubt the Non-Aligned Movement played an important role in directing WARC recommendations towards these ends. Communication technology has the potential to engender a benevolent aggression on development in the remotest areas of the developing world (See Jussawalla 1980).

The possible potential of WARC outcomes on equitable access for people in the developing world cannot be underestimated. Dr. Heather Hudson (1980) has rightly pointed out that it might be sufficient for the villager in a developing country to just talk to other villagers in his region via telephone and to regional headquarters and the capital city. Tongan people are cited as using INTELSAT to reach their relatives in New Zealand.

It is not just the economic interests of the North and the South that have been touched by WARC '79 but the human dimensions of the problems of poverty and inequity. Important policy issues stemming from the Conference are those related to the new realities of the international system and their acceptance by the First World. WARC outcomes pose a challenge to transnational communication corporations to alter their policies and operations, to meet the needs of developing areas and to international agencies like the ITU and UNESCO. It has accomplished concrete gains for both the North and the South. This is the first time the developing world has been able to compel action-oriented planning to meet its needs. The three major conferences that are designed to achieve just this are the Space Conference, the HF Broadcasting Conference and the Plenipotentiary Conference. It may not be an exaggeration to claim that WARC outcomes have set the stage for implementing those recommendations of the MacBride Commission which will foster a New World Information Order.

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A MICRONESIAN COMMUNICATIONS SURVEY

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ABSTRACT

This paper describes a communications survey of Micronesia (Trust Territory of the Pacific Islands) conducted by four employees of GTE. The paper includes the observations, objectives, findings, and recommendations of the group as related to their trip. The Trust Territory of the Pacific is on the verge of obtaining independent nation's status, and as such, the enhancement of the islands' communications facilities will play an important role in the development of the new nations.

1. INTRODUCTION

In June - July 1979, a four-man team of communications personnel from GTE had the opportunity to conduct a survey of the communications facilities and requirements in the U.S. Trust Territories of the Pacific Islands (Micronesia). The survey resulted from liaison and cooperation between the Micronesian officials and Hawaiian Telephone Company.

Hawaiian Telephone is a subsidiary of GTE and has a keen interest in helping in the communications development of the Pacific Basin. As such, a member of the team was Bob Engelbardt, International and Business Relations Director for Hawaiian Telephone. Other members of the team included Dick Houlette from GTE's office in Guam; Chris Paramithas from GTE Sylvania Systems Group in Needham, Massachusetts; and myself from the GTE Communications Products staff in Stamford, Connecticut.

2. TRUST TERRITORY OF THE PACIFIC

The communications survey involved the Trust Territory of the Pacific Islands which included the areas that have been known as the Marshall Islands, the Caroline Islands, and the Palau Islands. The Trust Territory has been administered by the United Stated Department of Interior, but of course, the islands are now on the verge of becoming three independent nations, namely, the Marshall Islands, Federated States of Micronesia, and Palau. Collectively, the islands span approximately 2,500 miles of the Pacific Ocean from east to west.

The actual on-site survey included visits to all but one of the district headquarters of the Trust Territory of the Pacific Islands. This encompassed the islands of Majuro in the Marshall Islands; Ponape, Truk (Moen), and Yap in the Federated States of Micronesia; and Koror in the Palau Islands Kosrae was not visited due to difficult access in relation to our scheduling constraints.

In preparation for the survey trip, each member of the team gathered and reviewed available published material about the history, people, economy, and politics of Micronesia. Much of this information related to the status negotiations concerning the forthcoming independence of the Trust Territory. The status negotiations have been going on for a few years.

A key element of the negotiations concerned the financial support to be provided by the United States following the independence of the individual Trust Territory nations. It was obvious to us that the status negotiations, the pending independence, and the prospective funding (which included the upgrading of telecommunications) would have an effect on our communications survey and any resultant recommendations. This takes us to a brief mention of the assumptions for our survey.

3. ASSUMPTIONS

Relating to the status negotiations between the prospective Trust Territory nations and the United States Government, we made the assumption that we were in actuality conducting three surveys. As such, the visit to Majuro would represent the requirements of the independent nation of the Marshall Islands.

Similarly, the visits to Ponape, Truk, and Yap would be used to reflect the requirements of the Federated States of Micronesia which would also include Kosrae. Finally, the visit to Koror would address the needs of the Palau Islands. We had decided in advance to conduct the three surveys independently, to review the results separately, and to prepare three distinct sets of recommendations. This was done to respect the pending independent nation status.

Another key assumption surrounded capital funding resources. We assumed from our readings and personal contacts, that communications was a high priority for development of the area, but funding would be limited since many other needs would be competing for funding allocations. Therefore, it became our purpose to identify communications requirements and solutions that would conserve capital, yet provide the remedies to the most pressing communications priorities.

Finally, we determined from our advance research that all aspects of the Micronesian telecommunications network needed to be surveyed for development In other words, we were not going to concentrate on any one aspect and provide a partial answer to the area's communications requirements. This, of course, relates to the funding constraints and therein calls for a balanced program of communications upgrading. To us, this translated to addressing the needs of the local network on each island (central office and outside plant) as well as the long distance (interisland and rest-of-world) requirements.

4 OBSERVATIONS

Before getting into the observations relating to the communications facilities and requirements, let me very briefly take you to each of the district islands that we visited. Each island had a most distinctive look and flavor of its own. Majuro is a long narrow atoll ranging in width from only a few hundred feet to over a mile in several places. A single 32 mile paved road extends the length of the unbroken section of the atoll. The island displays primarily a sandy to rocky beach atmosphere with some areas of fairly heavy tropical foliage. The majority of the 8,000 inhabitants live in the town of Rita on the eastern end of the atoll. The smaller village of Laura lies on the extreme other end of the island.

The island of Ponape has been designated as the capitol of the Federated States of Micronesia. The island itself, which is surrounded by a barrier reef and a lagoon inside the reef, is a lush, tropical, and mountainous area of great beauty. The rainfall is heavy and the island is dominated by hundreds of streams. About 4,000 people live in the district center and the principle town is Kolonia.

Truk is actually a large lagoon which is formed by a huge barrier reef. In the lagoon lies many mountainous islands, some with famous World War II names such as Japanese naval strongholds of Dublon and Eten. The lagoon contains the sunken wrecks of more than 60 Japanese warships and is an internationally.known favorite location for divers. The principle island and district center is Moen with a population of 7,000.

Yap was the third district center visited in the Federated States of Micronesia and is unique for the way the Yapese are retaining the Micronesian way of life. The economy and culture reflect the old ways of life in the islands - gardening, food gathering, fishing, crafts, native dress, and traditional feasts. Only in the district center of Colonia are there any significant signs of modern life.

Koror is a growing commercial center and the district center for the Palau Islands with a population of 7,000. Koror has an established fishing and tourist industry. The Floating Garden Islands near Koror reflect the beauty of the Palau Islands. Koror was our western most point being only 500 miles from the Philippine Islands.

4.1 LOCAL EXCHANGE FACILITIES

The visits to the aforementioned district islands revealed many similarities with respect to existing telecommunications facilities as well as future requirements. Each of the district center islands visited had telephone service established. In each case, local dial telephone service was provided by a single step-by-step switching system ranging in size from 100 to 300 lines. All central offices were fully utilized and in need of expansion or replacement. In all but one case, space was available for additional equipment and could generally accommodate a well-planned on-line conversion to a compact electronic switching system.

The outside plant network on the islands was generally matched in capacity to the central offices, and therein is also in need of expansion for existing demand as well as near term growth requirements. Unlike the central office equipment, however, much of the outside plant, which is plastic insulated, appeared to be in only fair condition. Cross connect (ready access) terminals were generally in a poor state of disarray. Aerial plant is subject to high wind damage and subscribers complain of noise and poor transmission, especially when it rains.

The local exchange networks on each of the district islands basically serve governmental and business requirements with very minimal residential service. Immediate satisfaction of known requests for service would roughly double the size of the existing telephone networks. Obviously the long-term growth potential is several fold and must be coupled to and integrated with the economic development of the islands. The "economic" refers to the availability and allocation of capital, the economic viability of the telecommunications operation, and the economic basis for an increasing number of subscribers who need and can afford telephone service.

The local telephone networks on each of the district center islands is operated by the Public Works Departments and is operationally independent of the long distance network facilities which have been administered by the Trust Territories. Interconnection between the two networks is made at the Trust Territory high frequency (HF) radio transmitting communications building on each island.

4.2 LONG DISTANCE FACILITIES

The survey of the long distance facilities used both for interisland calling and access to and from the rest-of-the-world (ROW) revealed more similarities between the district island centers of the three nations. Throughout Micronesia, the long distance facilities consisted of high frequency (HF) radio. Communication with the ROW is accomplished via 5KW redundant HF radio systems from each of the district centers to Saipan where access to the outside world is obtained.

The interconnection with the local exchange networks and all operational aspects of setting up an international or interdistrict call are manual. Several typical calls were observed. At least 10-15 minutes were required to set up a call by a HF communications center technician using a 5 button key set. There is no call supervision so the call must be monitored for disconnect. We observed 40-60 calls per day booked, but most were never completed.

Communications is extended to the myriad of Micronesian outer islands via 1 KW HF radio links. The outer islands can be patched through the district HF transmitter communications centers for access with the Saipan HF radio systems.

The bottom line is that the HF network is not the ongoing answer for the communications requirements of the Micronesian nations. Although the systems appeared well engineered and moderately well maintained, the resulting service must be considered marginal in this day and age. As mentioned, we observed and users complained of intermittent and generally poor level of transmission.

From a cost, priorities, and results standpoint, the effectiveness, or lack thereof, of communications to the ROW should be regarded as a high priority. The long HF links to Saipan add up to inadequate communications in terms of capacity, quality, and reliability. On the other hand, the HF systems linking the outer islands still represent an economically appropriate and realistic means of communications considering resources, population densities, and the outer islands' current state of economic and technical development.

The telecommunications requirements with the ROW and between the key island governmental centers was identified as the highest priority relating to both self government and economic development of the area. Inadequate long distance communications was observed to be an impediment to economic activity. For example, the tourist industry would require first-rate international communications as a prerequisite for growth. We could picture a significant tourist industry being developed in the Micronesian Islands, but not under the existing communications environment. Our own hotel accommodations, for example, were not reliably waiting for us as a direct result of the communications constraints.

Industry and business in general sorely needs telecommunications for timely ordering of materials and supplies, for carrying on marketing activities, for airline and hotel reservations, and so forth. The island's government needs reliable telecommunications to coordinate their increased activities relating to their independence, maintain international relationships, and respond to the needs and projects of a growing society. All of these current communications deficiencies and their effects were both repeated to us over and over, as well as observed firsthand.

5. OBJECTIVES

As we surveyed the facilities and met with governmental officials, we began formulating network plans which would achieve the following objectives:

A. Vastly improve international and interdistrict center telecommunications in terms of capacity, quality, and reliability.

B. Expand and modernize the local telephone exchange plant including central office equipment, outside plant, and terminal equipment.

C. Provide basic service improvement to the greatest possible percentage of the Micronesian population.

D. Conserve initial capital expenditures in keeping with funding limitations associated with forthcoming independent status, yet facilitate future growth of the telecommunications network.

E. Concentrate on initial telecommunications improvements that will enhance the economic development of Micronesia and that are economically viable projects in and of themselves.

F. Propose solutions that are relatively easy to implement and have a very low degree of risk associated with their operation. (Micronesia is a long distance from most forms of technical assistance.)

Although the above objectives are broad, they do provide guidelines for us to formulate realistic solutions. A related aspect which we were unable to get a finite handle on was the magnitude and availability of telecommunications funding. This contributed to our decision to recommend economically conservative solutions.

6. RECOMMENDATIONS

Keeping our self-imposed assumptions and objectives in mind, we arrived at proposed recommendations for enhancing the communications capabilities of the area. As planned, separate proposals were prepared for each of the individual island nations. Due to the similarities between the islands, as observed in our surveys, the individual proposals bear quite a resemblance to one another. Therefore, I can briefly describe the general approach without getting mired down in site peculiar specifics.

6.1 LONG DISTANCE RECOMMENDATIONS

The most significant investment would involve the installation of satellite earth stations (Standard B) in Majuro to serve the Marshall Islands, in Ponape and Truk to serve the Federated States of Micronesia, and in Koror to serve the Palau Islands. This was considered a minimum solution to address international and interdistrict telecommunications. If funding would permit additional sites, then earth stations (Standard B) in Yap and Kosrae should be included, in that order of priority.

During the communications survey trip, prospective earth station sites were studied and engineering data gathered to facilitate accurate cost estimating for each of the islands. In each case, more than one site was surveyed to ensure an acceptable location from a detailed engineering standpoint. Detail proposals for the optimum earth station sites have been prepared and submitted to each of the Micronesian nations for their respective locations.

The international satellite operation was proposed utilizing an INTELSAT satellite and terminating in the COMSAT Standard A earth station in Hawaii. By homing on Hawaii, several advantages were foreseen relative to the economics and the ease of implementation of the Micronesian systems. The satellite facilities would terminate in the large international gateway switching system operated by Hawaiian Telephone with access to their mechanized international operator system (TSPS - Traffic Service Position System).

Hawaiian Telephone has a wide range of direct high quality submarine and satellite circuits throughout the Pacific Basin including Guam, Fiji, American Samoa, Tahiti, Hong Kong, Philippines, Australia, New Zealand, Taiwan, Japan, Korea, Singapore, Thailand, and the mainland United States The established international operator system in Hawaii would greatly lessen the initial equipment, operations, and manpower problems associated with implementing international telecommunications. Procedures in Hawaii are well established, and, therefore, the incremental cost, operating expenses, training, and risks associated with the implementation in Micronesia would all be held to a minimum.

In addition, Hawaiian Telephone would assume half of the INTELSAT channel costs and would assist in arrangements for access to INTELSAT. Hawaiian Telephone would also provide international revenue settlement accounting services as well as a wide range of technical and operations support.

Each of the initial earth stations were recommended to be equipped for six communications channels of which two would be dedicated for use as order wires for COMSAT and INTELSAT respectively. With permission from INTELSAT, up to three telegraph circuits could be derived from one of the channels to fulfill telex and data requirements. The initial quantity of recommended circuits would allow for substantial stimulation of calling as compared to present HF system traffic. Our experience has been a several-fold increase in calling rates when a reliable, high quality satellite system is implemented. The earth stations, as engineered in the proposals, would allow expansion to fifteen channels with only modest incremental investments.

If earth stations were not provided for Yap and/or Kosrae initially, as an alternative, the HF radio systems presently homed on Saipan could be realigned to home on Truk and Ponape respectively to increase the utilization of and derive more benefit from the satellite facilities. In any case, the outer island residents would continue to use HF and VHF radio to their respective district center but would then realize the benefit of satellite transmission for international and interdistrict calling.

Our approach to the long distance requirements represented a compromise. We tried to provide the necessary improvements with respect to capacity, quality, and reliability, but we also deliberately kept a wary eye on first cost and operating expenses. We could have proposed both a larger system and a somewhat more sophisticated or complex approach, but, in our view, it would not have been consistent with the overall priorities of the area, the observed requirements and projected traffic, and the economic viability of the communications system. We also considered the matching improvement of the local exchange networks to be of nearly equal importance for the development of the area. Certainly the expansion of local exchange facilities to meet existing demand as well as future growth is a must.

6.2 LOCAL NETWORK RECOMMENDATIONS

To address the needs of the local district island networks for expansion and modernization, GTE's new rural electronic automatic exchange (REAX) appeared tailor-made for this environment. Designed to provide modern solid state, stored program features and reliability in a stand-alone application for relatively small line sizes, we recommended its application in each of the district centers. The initial sizes for each location would care for near term growth requirements including the pent-up demand. If and when long-term growth requirements exceed the ultimate REAX capacity of about 2,000 lines, then these versatile, modular, and easily containerized switching units can be readily and economically relocated.

We found that the space required for an REAX was so small that in all but one instance the limited central office room in the buildings in each district center could accommodate an on-line turnaround to accomplish the conversion. Although the benefits to be derived are numerous, some have more impact than others in Micronesia. For example, operational labor cost savings are not a significant aspect in Micronesia, but the extreme reliability and low level of maintenance and technical support is relevant. Improved quality of service, economical expansion, and flexibility are also important.

The switch replacement aspect of the proposals offer the required near term growth as well as the attributes of electronic switching at an unusually low cost. If, however, funding limitations preclude this approach, we are ready to offer used step-by-step equipment which is becoming available in Hawaiian Telephone as well as the other GTE operating telephone companies. This equipment is available as a result of the aggressive central office modernization (replacement) programs in Hawaiian Telephone and the other GTE companies. The used step-by-step equipment could be used in Micronesia to satisfy immediate requests for service without making a large or long-term capital commitment towards perpetuating the step-by-step technology.

Regarding the outside plant network, our approach was basically one of offering, via the expertise of Hawaiian Telephone, to properly engineer the necessary outside plant relief and then to supervise the outside plant implementation. We recommend that local personnel be utilized for the actual installation to serve as on-the-job training. Hawaiian Telephone would also provide maintenance training to complete the knowledge transfer process.

Incidentally, while in Majuro, an urgent requirement for either a key telephone system or a small PABX was identified for a new government building. As a follow-up item from our trip, Hawaiian Telephone offered a key system from their stock to meet this rapid requirement. The offer was accepted and the system was shipped and installed by local technicians with assistance from Hawaiian Telephone.

Our recommended exchange network expansion and modernization program would complement the implementation of the satellite earth stations. The plan would provide for the economical introduction of International Direct Distance Dialing (IDDD) with Automatic Number Identification (ANI). This will give a significant percentage of Micronesia direct access to the diable telephones in the ROW. A by-product of the IDDD implementation will be to minimize the use of international operator assistance in Hawaii. The operator assistance will be available when required, but will be of such a small incremental proportion that it would further support our contention that separate multiple operator facilities need not be initially established in each of the Micronesion entities.

7. SUMMARY

Many more details of our trip and the individual telecommunications aspects of each of the district communications centers could be discussed, but then we would be looking at a very long paper. I will spare you from that. Suffice to say that the communications requirements, despite many similarities, for the forthcoming separate government entities of the Marshall Islands, Federated States of Micronesia, and Palau also varied with the geographical differences between the respective island nations.

For example, the Federated States of Micronesia have four far-flung island states for which an optional direct interisland satellite system could be provided. It was our opinion that this would constitute a supplemental optional configuration depending upon funding and feasibility aspects. Therein, we have subsequently provided detailed engineering modification information to demonstrate how the above network plan had the flexibility to be modified using the same single earth stations per site to provide direct interisland dialing in addition to the IDDD via Hawaii.

Incidentally, we did not observe a significant level of interdistrict island traffic and felt that the basic arrangement via Hawaii offered the most feasible combination of economy and service at this time. Of course, it is equally important to be able to modify the initial approach to address future communications requirements and incorporate technological advances and this is taken into account in our planning.

In conclusion, we found the trip to be personally rewarding. The officials and all personnel encountered on the survey were most helpful, cooperative, interested, and friendly. We are most anxiously awaiting responses to our recommendations and proposals; it might even give some of us an opportunity for a welcome return to visit these wonderful islands once again.

I couldn't help wondering at times if the technological and economic development that we are fostering for the area will really mean progress in a philosophical sense. Then I get a hold of myself and remember that I make my living in this line of work, and that I would not want to give up the benefits of our highly developed technological society. After this bit of rationalizing, our survey trip and its purposes once again seemed to make sense to me.

Computers in Education: International Multi-Mode Node Electronic Conferencing

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ABSTRACT

This paper discusses a revolutionary approach to international conferencing on the topic of computers in education. The project was motivated by the need on mid-Pacific islands for up-to-date information on computer hardware and software, and a desire for current information in the fast-developing field of educational computing.

In this remote island setting, information about current experience with computer-based instruction was difficult to obtain, and discussion with peers was slow and inefficient by traditional methods. When introduced, the novelty of computer use in the island environment evoked an immediate interest among island educators.

The Computers in Education series took place by means of the "Multi-Mode Node" (MMN) technique linking electronically incompatible telecommunications resources. The systems utilized were the NASA ATS-1 PEACESAT satellite communication system, the Electronic Information Exchange System of the New Jersey Institute of Technology, and the University of Illinois PLATO computer system. Descriptive information on the motivation, setting, planning, and subsequent conference sessions is presented in this paper. Samples of the computer-stored discussion are included. Future plans involving data transfer experiments are also introduced.

I. PEACESAT Meets Need for Information Exchange

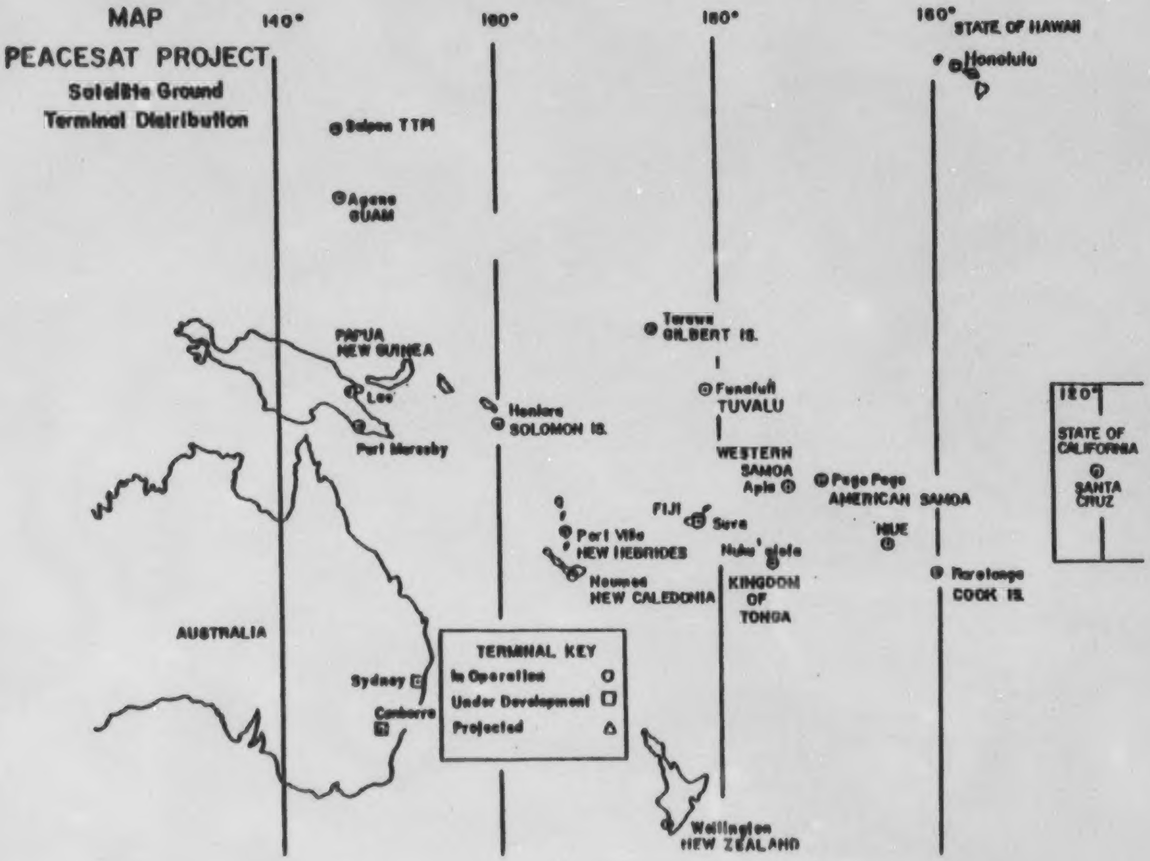
During midyear 1979, when educators at American Samoa Community College were in the process of deciding to introduce computers into their curriculum, they desired to determine the extent to which computers had been used in education in similar environments in the Pacific islands. A series of conferences was suggested by Flanigan, using the PEACESAT (Pan-Pacific Education and Communication Experiments by Satellite) network and the ATS-1 satellite (1). The initial responses from the various locations with PEACESAT ground terminals (Figure 1) indicated three things of interest: 1) no educational institution on any of the small islands represented was using computers for educational purposes, 2) there was broad interest in the prospect of computer-based education, and 3) there were sincere concerns regarding the problems of implementing computer-based education (CBE) in remote tropical locations. There was a general lack of experience in the implementation of computer education in the remote island environment.

A series of seminar-like PEACESAT sessions were held between June 1979 and June 1980 with topics relevant to computers in education selected in advance. By utilizing a system of rotating chairpersons, increased workloads for individuals were minimized, and instructors in Wellington, Honolulu, Sydney, and Santa Cruz were able to freely exchange ideas. Those who were already using CBE were able to talk with those in the islands who had had CBE experience elsewhere and were interested in applying their knowledge to the educational needs of their students.

II. Computer Conferencing Adds Asynchronous Capability

Computer communication and conferencing (CC/C) is being utilized increasingly as a means of bridging geographic and time barriers. Basically, CC/C utilizes central timesharing computers and geographically-dispersed terminals linked by telecommunications networks. A well-known system used in this project is the Electronic Information Exchange System (EIES) (2) by the New Jersey Institute of Technology's Computerized Conferencing and Communications Center. Founded in 1977 by Dr. Murray Turoff,

Figure 1


MAP
PEACESAT PROJECT
Satellite Ground
Terminal Distribution
140°
160°
180°
160°
STATE OF HAWAII
Honolulu
Saipan TTPI
Agana
GUAM
PAPUA
NEW GUINEA
Lae
Port Moresby
Honiara
SOLOMON IS.
Tarawa
GILBERT IS.
Funafuti
TUVALU
WESTERN
SAMOA
Apia
Pago Pago
AMERICAN SAMOA
FIJI
Suva
Port Vila
NEW HEBRIDES
Noumea
NEW CALEDONIA
Nuku'alofa
KINGDOM
OF
TONGA
NIUE
Rarotonga
COOK IS.
120°
STATE OF
CALIFORNIA
SANTA
CRUZ
AUSTRALIA
Sydney
Canberra
TERMINAL KEY
In Operation ○
Under Development □
Projected △
Wellington
NEW ZEALAND

EIES began as an NSF-funded project. It converted in April 1980 to a user-funded basis with approximately 700 subscribers, most of whom are located in the mainland U.S., Hawaii, Canada, the Caribbean, and Europe. Various subscriptions cost from $15-$100 per month with additional hourly communication charges. Most EIES users are linked to the EIES minicomputer via Telenet, which has hourly charges of $3.75 on the mainland U.S., $6.50 in Hawaii and Canada and more in other parts of the world. The basic EIES system supports electronic messaging, conferencing, personal notebooks, text editing, and document preparation. It includes a multitude of specialized features such as voting, automated questionnaires, and data-gathering to facilitate group processes. These are available for reading at any time.

EIES software is designed to allow users to develop their own subsystems. While CC/C is mainly used in the convenient off-line, asynchronous mode, EIES has several real-time, synchronous modes (i.e. +LINK, +SEN, and ???). EIES uses standard ASCII computer terminals with remote terminals usually running at 300 baud using ordinary telephones and low-speed Telenet lines.

Another time-sharing system is PLATO (Programmed Logic for Automated Teaching Operations). This system, designed specifically for CBE, was developed at the University of Illinois' Computer-based Education Research Laboratory (3)(4). Marketing rights are held by Control Data Corporation. PLATO uses a special plasma or cathode ray terminal with a 512 x 512 dot matrix display that ensures high-resolution graphics capabilities.

There are ten interlinked PLATO systems which permit extensive international computer communication networking. Personal notes and group notes are forms of computer conferencing regularly used for asynchronous communication. PLATO "term-talk" and "talkomatic" allow synchronous communication for two to five persons.

While synchronous modes can be most dynamic (e.g. with PLATO "talkomatic" allowing 5 persons to talk/type simultaneously), it also can be somewhat confusing and lacks permanent record of the discussion. Therefore, the alternative forms of asynchronous conferences and groupnotes tend to provide more order and permanence.

III. Multi-Mode Node (MMN) Techniques Broaden Participation

MMN is the coordinated use of electronically incompatible systems like audio satellite and digital, written computer conferencing. The MMN approach permits enhanced networking by participants having access to only one system (5). In the case of this project, the basic technique was to set up a computer terminal at the Honolulu PEACESAT Exchange Center (Illustration 1) to input satellite-transmitted dicussion summaries and to output comments written by those on the computer network for verbal transmission to PEACESAT participants. The EIES Public Conference 1021 (Computers in Education) was started and moderated by Southworth and has been the site for most MMN session summaries.

Until recently, use of PLATO in these conferences was somewhat restricted because of the difficulty in moving the heavy PLATO terminals from their permanent location to PEACESAT. The development of the lighter CDC IST II cathode ray terminal has made PLATO increasingly attractive as a possibility for MMN programs. The PLATO/CERL groupnotes "satellite" was used July 7, 1980, as the site for the MMN summary of the PEACESAT demonstration for the National Academy of Peace and Conflict Resolution Commission hearings in Honolulu. The "testimony" of Pacific basin PEACESAT users was a unique international aspect of the NAPCR hearings held in various locations across the United States. The establishment of "mmnnotes" on PLATO/CERL in July 1980 allowed for further experimentation and development of MMN techniques and programming.

IV. Sites and Settings of MMN Participants

Central to the Hawaii participation was the 1979-80 Cooperating Institutions' Agreement between the University of Hawaii and Chaminade University of Honolulu. Southworth provided the consulting and technical support and Knezek handled the fiscal and participatory details. As a part of their membership in EDUNET (6), Chaminade instituted an EIES group subscription. The group format permitted private subaccounts by institutional users (7). During the summer of 1980, Flanigan was able to utilize his own subaccount on EIES while visiting Indiana University. In addition, he had access to PLATO, so he could communicate via either system. (This paper was compiled using PLATO as the site for a joint file in which Southworth and Flanigan entered text and "met" for synchronous composition and review or exchanged asynchronous notes on form, syntax, and plans for the paper. Draft copies were printed at the University of Hawaii in Honolulu on an ASCII hardcopy printer, while the final version was prepared on a Xerox 850 Information Processor at Chaminade University of Honolulu. The text was electronically transferrred from PLATO to the Xerox via the bubble memory of a Texas Instruments Model 765 portable terminal.)

The Honolulu participants were either on-site at the PEACESAT Exchange Center at the University of Hawaii or, in the case of the Leeward Community College participants, were linked into PEACESAT via phone patch. On one occasion, representatives of EDUNET, the international computer network for higher education and research, called in from Princeton, New Jersey, and were able to converse directly with PEACESAT participants.

Some promising experimentation was done using the SSTV (Slow Scan TV) technique with computer and satellite modes for transmission of the dialogue and SSTV providing video communication. PEACESAT participants were located on the mainland U.S. (on the campus of the University of California at Santa Cruz), in overseas metropolitan centers (Sydney, Wellington, and Suva) and at smaller, more remote Pacific locations such as American Samoa (population c. 30,000), Saipan (population c. 12,000), Rarotonga (population c. 10,000), and Niue Island (population c. 4,000).

Illustration 1: Participating in a PEACESAT Conference via EIES, Honolulu 1980

John Southworth discusses an EIES display with U.S. Representative George Brown
(Courtesy The Printout Magazine, Honolulu)

Synchronous participation of EIES subscribers included persons in a variety of localities on the U.S. mainland and Canada. Since CC/C records remain on the computer for anyone using EIES anywhere at anytime, many asynchronous participants also reviewed the various topics being considered.

V. Computers in Education Conference

Initial discussion centered on the practicality and practicability of introducing computer-based education to the islands. Well-considered apprehensions were expressed from various locations about environmental requirements, reliability and maintenance problems. The ramifications of encouraging such advanced technology in these locations were discussed. The capabilities of the PEACESAT to support synchronous discussion from widely-spaced locations resulted in the resolution of these concerns to the satisfaction of most participants. It is doubtful that any other means of communication could have supported participation from those remote locations. Through MMN sessions it was demonstrated that attempts to implement suggestions on a real-time basis were practical. The microcomputers are portable and were set up at PEACESAT terminals where operators responded to comments from other terminals. In this way it was possible for educators at institutions in the smaller islands to utilize expertise from the metropolitan institutions in a timely and cost-effective manner.

A spin-off of these conferences was a series of meetings between groups of students with Southworth and Knezek in Honolulu and Flanigan in American Samoa. These students were able to converse about programs, programming and the general area of computer activities. An extension of such contacts could support other presently-unavailable resources such as career counselling.

VI. Examples of CC/C Dialogue

During the October 18, 1979, session (entitled "The Relevance of Computers in Education on Smaller Pacific Islands"), Bill Bartlett, conducting research in the development of telecommunication services on a small island in Canada, stated:

(EIES C1021 CC66 10/19/79 12:07 AM EST)

> I'm coming over EIES from one of the North Pacific islands off the coast of British Columbia. I'm interested in finding ways in which I can introduce computers in a way that won't frighten the teachers and will gain school board support.

Alan Creswell in Rarotonga added (CC68 12:24AM):

> I can't see the relevance here at the moment. There seems to be such a gulf between islands which have the capability. But here it "sounds very nice" but is not possible now.

Gerald Knezek in Honolulu commented in the same item:

> We have about 200 Pacific island students. We find the students seem to be just as able and maybe even more excited about learning.

Bartlett added (CC69 12:37AM):

> I think it's as important to show students appropriate applications for the computers, both in an educational context, and in how they are being used in business, world trade, politics, communications, and just how they might relate to life in the south Pacific, now or in the future. Educational introduction of computer technology may, in fact, start from ways in which they are used in other applications and countries, and let the students decide for themselves just how they might relate to island life.

Creswell then cautioned (CC70 12:45AM):

> We don't even have TV so the question is how do you introduce computers?

Liza Loop in Santa Cruz challanged all with her comment:

> I think it is an exciting question: Should computers be introduced before TV? I introduce computers to young children as "interactive" TV. I think it would be exciting to see how it would go to introduce it as the primary tool rather than passive TV. Control over technology is a big point about the value of computers over TV or radio. I think you could do some very exciting things.

Thus, within one hour, educators from the mainland and Pacific basin experienced in CBE were able to "meet" and "talk" intimately and conveniently about issues of vital concern for future applications of educational technology.

VII. Concluding Comments and Future Plans

It appears that the application of computers to education in the small Pacific islands is in its infancy. We uncovered a large pool of experience in the U.S., New Zealand and Australia in the use of computers in the education of minorities, and found that educators in the smaller islands were very receptive to the opportunities presented by the experiment on PEACESAT. MNN conferencing made possible the discussion of issues with others who were active in the field. Information from peers was made available in a synchronous mode, which was a great improvement over unsatisfactory traditional methods.

The most recent Computers in Education sessions have concentrated mainly on three things: 1) areas of study in which CBE is practical for the target students, 2) techniques of CBE implementation and 3) possibility of linking microcomputers at various locations. The first and second points are yet unresolved; the experience gained has been only two semesters, in American Samoa. But the University of the South Pacific in Suva Fiji, has recently acquired microcomputers, which will be used at U.S.P. extensions, such as Niue Island, Western Samoa, Tonga, Kiribati, New Hebrides, the Soloman Islands, and Tuvalu, as well as in Suva. They have already begun to accumulate relevant experience. The third point involves the exciting possibility of using the PEACESAT network to link microcomputers in the various locations. Attempts to demonstrate the feasibility of such experiments were carried out between Suva, Honolulu and American Samoa. On May 29, 1980, a program and data were transmitted by John Lovell at the University of the South Pacific, using an Apple II with a modified D. C. Hayes micromodem, to the PEACESAT terminal in Honolulu where it was captured by Knezek using a Texas Instruments 765 bubble memory terminal. Intermittant bursts of static caused certain parts of the transmission to have high error content, but the over-all error rate was less than 0.4 per cent. Since the seventeen transmission errors in a 105 line program sent from Fiji to Honolulu (in about three minutes) were quickly corrected by comparing the texts from just two program transmissions, it appears that this medium offers an opportunity to develop the capability of exchanging data and programs using microcomputers.

This continuing conference is an example of MMN capabilities of PEACESAT/EIES/PLATO. Educators located in institutions isolated by limited communications are using MMN techniques to meet with resource people and with each other to develop educational opportunities for island populations in areas of computer science. The potential for linking these islands using microcomputers and the PEACESAT network offers unanticipated opportunities for the island educators to introduce modern instructional methods to enhance educational opportunities for their students.

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Communications for Small Communities
In Developing Countries

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Abstract

A high frequency radiotelephone system offering enhanced performance compared to that of existing systems is described. The enhancements include real-time channel evaluation and the capability of interfacing to existing telephone systems without the need for operators. Results of preliminary on-the-air field trials indicate that the new system is reliable and exceptionally easy to use.

1. INTRODUCTION

The 1980 Pacific Telecommunications Conference included a session entitled "Geographic Isolation: Are Satellites the Only Answer?" A paper in that session by L.J. Carter(1) of Papua New Guinea puts forth some convincing arguments in favour of improved HF communications as a more "appropriate technology" for serving small communities in developing countries. Some of these arguments may be summarised as follows:

- An HF based radio-telephone service is inherently low cost; the ionosphere is free.

- An HF system, once purchased, is entirely within the control of the country it serves while no small, developing country can expect to own a satellite.

- Once an HF system is in place there is no major flow of money out of the country to maintain it as in the case of rental of a satellite transponder.

- Elements of the HF system, particularly antennas, can be built with local labour using inexpensive, locally available materials.

There remain, nevertheless, certain disadvantages of HF, notably the need for skilled operators to cope with inherent variability of the ionosphere, the necessity to identify a frequency providing adequate transmission for any given call, and the difficulty of effective interconnection to an automatic telephone system.

The purpose of this paper is to describe a new development in HF radiotelephone systems which responds to the needs and problems identified above. This development provides an HF radiotelephone link which can be interconnected to automatic telephone systems at one or both ends on a fully automatic basis; no operator is required. Reliability is greatly enhanced by automatic, real-time channel evaluation and selection of the best available frequency.

In a related development, a new voice processing system has resulted from efforts to improve the voice quality obtainable on an HF/SSB circuit. This system, called Syncompex, is a linked compandor implemented using digital techniques, and was designed to be a less expensive alternative to the well-known Lincompex system (2). Although it plays an important role in the new radiotelephone system, the Syncompex system is a separate entity and could be added to existing HF links. This development is described more fully in a companion paper (3).

The developments described were carried out by the Department of Communications of the Government of Canada and were initially intended for application in remote communities in northern Canada and in shipping operating in Canada's coastal waters. We believe they are ideally suited to serving remote and rural areas of developing countries.

An experimental three-station HF network has been constructed and has undergone field trials in eastern Canada. No interconnection to existing telephone networks was available for these trials. Upon completion of this phase, the system will be deployed in British Columbia. Interconnection to the Trans Canada Telephone System will then be carried out and evaluated.

2. BACKGROUND

High Frequency radio has been used for decades to provide long distance telecommunications via ionosperic modes of propagation. However, the variability of the ionospere and high levels of background radio noise have made HF radio less than satisfactory as an adjunct of a telephone system. Experience in northern Canada has shown that skilled operators are required to achieve circuit reliabilities approaching 70%. The ionosphere is dynamic in nature, requiring the operator to effect frequency changes to accommodate the predictable components of ionospheric variation (diurnal and seasonal) as well as the unpredictable variations due to solar activity. This is frequently beyond the ability of radio operators. In areas in which skilled operators are not available, the level of success may be considerably less than 70 percent. In some systems where HF radio is interconnected with the telephone system, operators have been required to operate transmit/receive switches according to the content of the users' conversation, which the operators had to monitor. The circuit interconnection itself is often a manual process because of difficulties in accommodating conventional telephone dialling and supervisory signalling over the HF radio path. Equipment reliability has frequently been less than satisfactory because of the dependence on obsolete technology to obtain the kilowatt power levels sometimes considered necessary to overcome poor propagation conditions. The combined effect of these and other difficulties has resulted in the general abandonment of efforts to improve HF radio performance in favour of newer communications techniques such as satellite radio relay.

Although techniques for solving many of the problems associated with HF radio systems have been known for many years, the expense involved in their implementation and maintenance has generally precluded their use. The advent of modern integrated circuit technology, however, has changed this situation considerably; the result is the system described below.

System Characteristics

As indicated above, the thrust of the DOC sponsored development project is to produce an improved HF radiotelephone system that can be directly and automatically interconnected with the domestic telephone system. Specific characteristics that the new system offers are:

(a) a probability of circuit availability exceeding 90%.

(b) a high level of equipment reliability to minimize the need for preventive maintenance or spare installations.

(c) automated operation to eliminate the need for highly skilled operators.

(d) direct dial access to and from conventional telephone systems.

(e) noise reduction and improved speech quality.

(f) relatively low cost for civilian users.

Circuit availability is maximised through the proven concept of real-time channel evaluation. This is achieved through use of frequency agile transceivers coupled to wide band antennas, and rapid testing of the radio circuit on each of the available frequencies to ensure that the best one is chosen for the subsequent call. Microprocessor control of the channel evaluation process permits fully automatic operation, thereby eliminating the need for an operator and facilitating automatic interconnection with a telephone system. Real-time channel evaluation represents a step beyond frequency prediction programs because prediction cannot account for factors such as ionospheric disturbances and interference from distant stations. These factors have a strong influence on the selection of a frequency channel.

Noise reduction and speech quality improvement are provided by the Syncompex system, referred to earlier. All of these features together greatly facilitate the problem of interconnecting an HF/SSB simplex radio link to a conventional telephone circuit. The Syncompex system has been tested as a separate entity up to now, but will be incorporated in the HF system at a later date.

System Operation

The three-station experimental system deployed in eastern Canada during the spring of 1980 is depicted in Figure 1. Two types of remote station are shown, one having a single telephone, and the other interconnected to a small PABX switch in order to serve a larger community. Since the master station would normally be located in a larger community, it was also provided with a PABX switch. This switch could be eliminated if not required to service subscribers in the vicinity of the master station; its presence is not required in order to interface the HF radiotelephone to the switched network. In order to demonstrate the capability of extending access to an HF terminal by means other than metallic conductors, a low power 450 MHz voice link was connected to one port of the switch. A VHF or UHF carrier system such as this could just as easily be connected to a remote station for extended area coverage.

All subscribers in the system are assigned seven digit numbers according to the standard numbering plan; however, abbreviated (three digit) dialling is used for calls within the HF network. An access digit is used to differentiate these calls from those destined for the DDD network.

When no calls are taking place in the system, the master station continuously cycles through the assigned channels (eight in the experimental system), transmitting a short digital message on each one. The remote stations synchronize themselves to the master station and maintain short-term statistics on the quality of the channels, derived from an examination of the integrity of the received data. The quality assessment is partly based upon detection of bit errors by means of error detection coding in the data. In addition, a "pseudo-error" measurement technique (4) is used to refine the selection process when several channels have similar error rates.

When a subscriber dials a number requiring the HF network, the master station and the appropriate remote station begin a "handshaking" procedure and jump to the channel selected by the channel evaluation algorithm. If the procedure is successful, the voice paths are enabled and the usual telephone call progress tones are transmitted to the calling party. If the HF network is

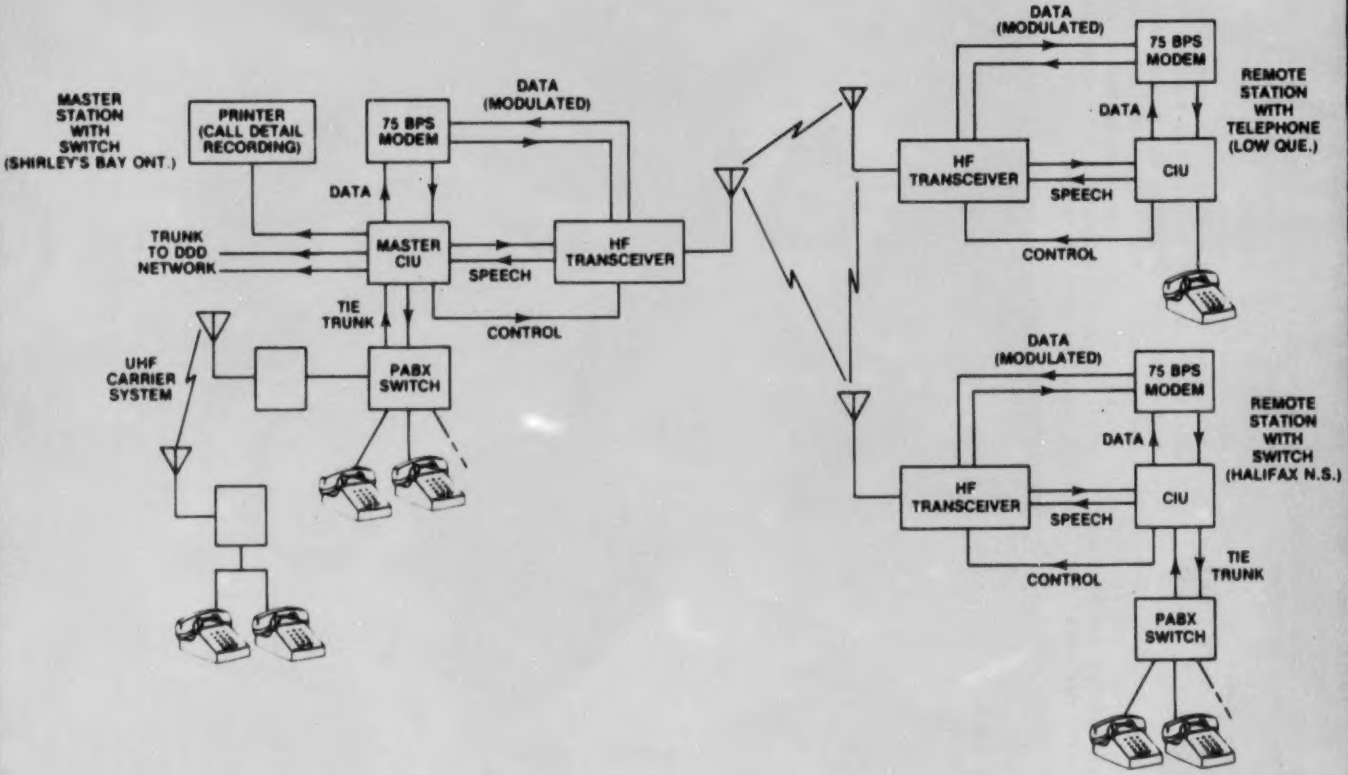
MASTER STATION WITH SWITCH (SHIRLEY'S BAY ONT.)
PRINTER (CALL DETAIL RECORDING)
75 BPS MODEM
DATA (MODULATED)
DATA
TRUNK TO DDD NETWORK
MASTER CIU
SPEECH
HF TRANSCEIVER
TIE TRUNK
CONTROL
UHF CARRIER SYSTEM
PABX SWITCH
DATA (MODULATED)
75 BPS MODEM
REMOTE STATION WITH TELEPHONE (LOW QUE.)
DATA
HF TRANSCEIVER
CIU
SPEECH
CONTROL
DATA (MODULATED)
75 BPS MODEM
REMOTE STATION WITH SWITCH (HALIFAX N.S.)
DATA
HF TRANSCEIVER
CIU
SPEECH
CONTROL
TIE TRUNK
PABX SWITCH

Fig. 1 Block Diagram of Experimental System Deployment

unavailable or the call setup procedure fails for some reason, a reorder tone is returned to the calling party as an indication that he should redial. When one party goes onhook at the end of a call, the HF station to which he is connected begins transmitting a digital "disconnect" message. This results in another brief "handshake" and the system is returned to the idle state.

In the case of a call from one remote station to another, the procedure begins as above, but the master station then stands by as the calling remote initiates a handshake with the called remote. When the call setup is complete, the master station returns to idle state and is available for other calls (the channel in use by the remotes is automatically busied out until that call is completed). The remote stations therefore communicate directly with one another during the call; this not only frees the master for other calls, but avoids the problems associated with operating two HF links in tandem.

Sub-System Characteristics

The experimental automatic HF station consists of an all-solid-state 100 watt HF/SSB transceiver, a broadband antenna, a 75 bps modem, and a controller/interface unit which provides the automatic functions and necessary interface characteristics for telephone compatibility. These system components will be described in detail in the remainder of this section.

The HF/SSB Transceiver - A 100 watt HF/SSB transceiver has been developed for this project which has the capability of being controlled remotely by a microprocessor to operate in one of eight preselected frequency channels. Since that development, we have noted that several types of commercial transceivers can be easily modified to operate in the system. It is important to note that the reliability of the system is largely dependent upon the transceiver and that selection of an expensive but more reliable transceiver will often prove to be more cost-effective in the long run. Emergency service calls to rectify equipment failures in remote areas can be very expensive and involve long delays.

Broadband Antenna - Since the HF system changes frequencies quite rapidly (every two seconds at present) while in the idle state, the antenna must be capable of providing a good impedance match at each frequency without requiring a significant amount of time or operator intervention for retuning. The frequency coverage required is quite large, typically three octaves. In addition, the antenna should provide, in many cases, approximately omnidirectional coverage. The most satisfactory means of meeting this requirement is generally a broadband dipole or monopole type of antenna. Three different antennas falling into this category have been used in our field trials and have provided good results. In some cases, however, as in shipboard installations, space limitations preclude the use of such an antenna. It then becomes necessary to use a narrowband type of antenna (such as a vertical whip) together with a matching unit which has presettable tuning and rapid switching. We hope to evaluate the latter approach in future trials of the system.

Modem - Interprocessor communication for control of the HF network is carried on by means of 75 bps modems at each station. The modems are standard asynchronous FSK units which have been modified for synchronous operation. In-band frequency diversity is used in order to improve the performance under selective fading conditions. When the Syncompex voice processor is included in the system, this modem can be eliminated, since the modem contained within the Syncompex unit can also be used for network control.

Controller/Interface Unit - The controller/interface unit (CIU) is a microprocessor-based system which provides the link between the telephone network and the HF radio network. The functions of this unit include:

(a) Generation and control of call progress tones.

(b) Generation and reception of dialled digits (via DTMF signalling for individual telephones or PABX switches, and MF signalling for the trunk connection to the switched network).

(c) Timekeeping and call detail recording.

(d) Interface to HF modem for interstation communication on the HF network.

(e) Control of HF radios: transmit/receive switching, channel selection, and mode (voice or data).

(f) Two wire/four wire conversion for voice frequency paths.

(g) HF channel evaluation.

The CIU is modular in nature, and is housed in a 7 1/2" x 19" rack-mount enclosure. The complement of circuit cards in a given unit depends upon the type of station (master or remote) and the type of telephone equipments to be interfaced. The CIU also contains a keypad and display to facilitate modifications and troubleshooting in the field.

3. TESTS AND EVALUATION

Tests of the experimental system were carried out using sites at Ottawa, Ontario; Low, Quebec; and Hammonds Plains, Nova Scotia. These sites were selected because they include a short skywave path of about 60 kilometers and a medium range path of about 1000 kilometers. Eight frequencies between 3 and 21 MHz were chosen as a suitable complement of frequencies.

During the initial part of the experiment, all sites were manned for several test periods and calls were made at five minute intervals around

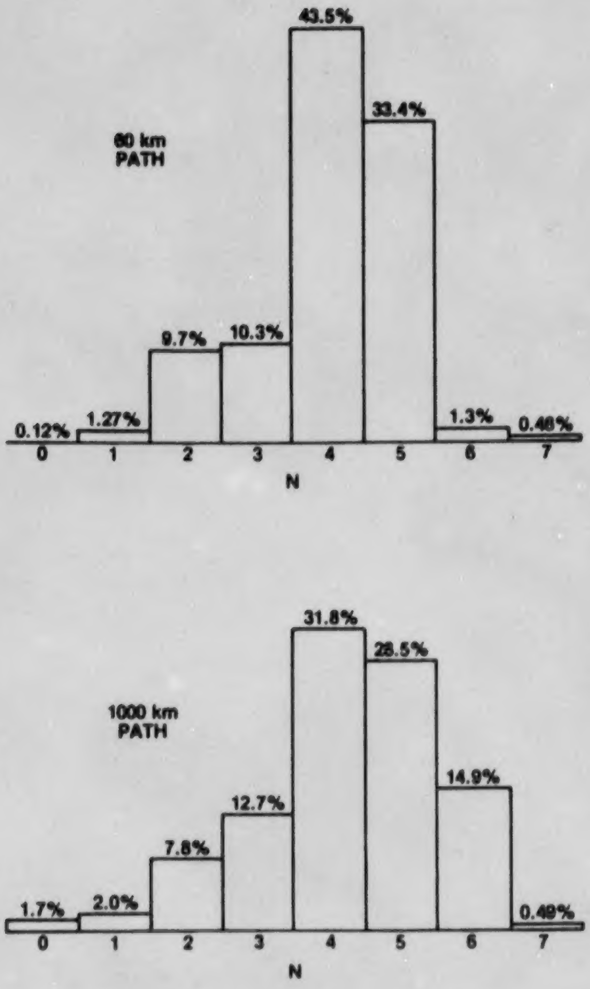

Fig. 2 Percentage of Test Period for which N Channels Exceeded Level 2 Quality

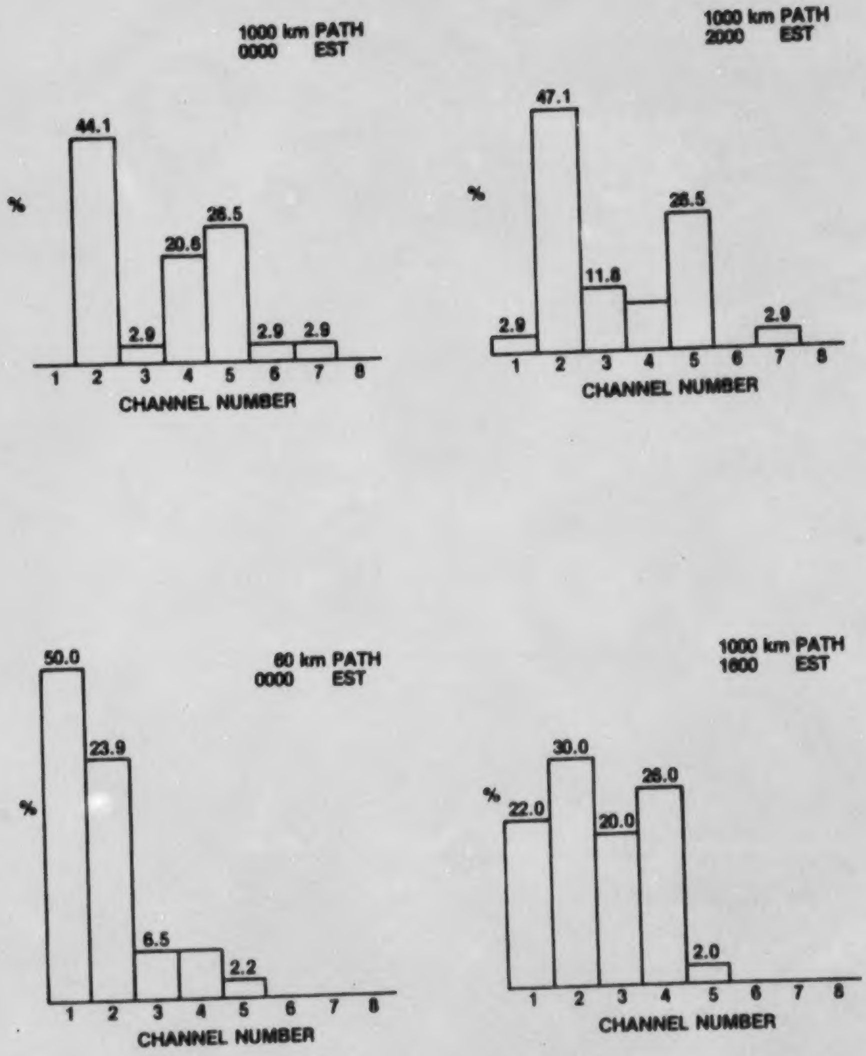

Fig. 3 Distribution of Best Channels at Various Times of Day

the clock. Well over one thousand calls were completed, and it became apparent that the objective of 90% or better availability was achievable. In order to gather more accurate figures on system performance, a lengthy period of continuous operation was then begun. This operation took place during April, May and June of 1980. Since it was not feasible to man the stations for this length of time, printers were installed at the remote stations to log the data on the quality of the channel sounding transmissions received from the master station. From these data it was possible to deduce whether a call could have been completed at a given time, and to make an estimate of the quality of ensuing voice transmissions. It is also of interest to note how many of the eight channels are actually useful on each of the paths as a function of time.

In analyzing the channel quality data, two levels of performance were distinguished. The first, which we shall refer to as level 1, is reached when the bit error rate on the channel is sufficiently low that virtually all digital messages were received without errors. Such a channel generally offers very good voice communications. The criterion for level 2, on the other hand, is that approximately one-third or more of the messages are received without error. This level was arrived at empirically and corresponds roughly to the lower limit at which voice communications can be carried on without major difficulties. Several dialling attempts will often be required when the channel quality is near this lower limit.

The results of the on-the-air tests were as follows: level 1 quality on at least one channel was attained for 84.2% of the test period on the 60 km path, and 77.7% of the period on the 1000 km path; for level 2 quality, the figures were 99.9% and 98.3% respectively. In other words, one or more useable channels were available on both paths for virtually the entire test period.

Several comments on these statistics are in order. First, although disturbed propagation conditions were encountered several times during the test period, including geomagnetic storms on at least two occasions, it is obvious that sustained blackout conditions were not encountered. Such blackouts are very rare events; however, their occasional appearance would tend to lower the long-term availability figures slightly.

On the other hand, the figures tend to be pessimistic, since they have not been weighted according to normal traffic patterns. The most difficult time for HF propagation is usually in the early morning hours prior to sunrise, which coincides with a period of very low traffic density. Thus a weighted availability figure would tend to be greater than the unweighted figure.

As shown in Figure 2, the test results demonstrated that there was nearly always more than one useable channel available for a given path; in fact, there were at least four channels available in the majority of instances. Moreover, the set of useable channels for two different paths at a given time is often quite different, particularly if the path lengths differ considerably. One conclusion that might be drawn from these observations is that the availability of a suitable channel for setting up a call tends to remain relatively high even if several of the total set of channels are busy. There is also a strong indication that fewer than eight channels would provide good service; however, it is difficult to generalize from the results of a trial whose duration was only a few months. It is worth noting at this point that one of the channels (channel #8, 20.5 MHz) was useful so seldom during the trials that it could have been omitted entirely with negligible effect on the availability figures.

Finally, the results of the on-the-air tests clearly demonstrated the value of real-time channel evaluation. Many instances of propagation well above the predicted maximum useable frequency (MUF) were encountered. On the 60 km path, for example, channels at 13.7 MHz and 20.5 MHz were useable on a number of occasions when the predicted MUF was in the 5-7 MHz range. Interference from distant stations sharing the same channel, another unpredictable element in HF communications, was also found to be a very important factor in determining the best channel to use. Figure 3 provides a graphic illustration of the unpredictable nature of HF channels and the utility of the real-time channel evaluation. The best channel, as determined by the channel evaluation algorithm, at the same time of day on successive days was recorded for each path. The percentage of days during the test period that a given channel was best at that time is shown by the histogram. The approximate frequencies of the channels numbered 1 through 8 were 3.2, 5.3, 6.8, 7.6, 9.4, 11.6, 13.7, and 20.5 MHz respectively. At 0000 local time, for example, one would normally expect the lower-frequency channels to propagate best; it can be seen, however, that the higher-frequency channels were best for a significant proportion of the time.

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Cooperation and Participation in Regional and International Telecommunications Standards

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Abstract

The information processing industry is bringing forth new products and services, such as interactive data processing and distributed data processing systems. The communications industry is bringing forth new services, such as Videotex, and facilities, such as channels for satellite and digital communications. Utilizing these significant telecommunications offerings will cause new problems in Regulation, Certification, and Standardization for users in the Pacific basin area.

1. INTRODUCTION

It is a pleasure to be able to participate in PTC '81.

The pyramiding growth of technology through the 60s and 70s in data processing as well as in the communications industry has opened many opportunities for new services. These developments have matured over the last decade and now is an appropriate time to take stock.

Pinpointing precisely where significant progress has been made and where these advances can lead us will identify the specific areas for attention by the PTC, many of which pertain to other parts of the world as well. CCITT[1] has just finished its seventh plenary session and established a program of work for the next four years. The two major contributors in the ISO[2], TC97/6 and 97/16, held meetings last fall. These meetings have been the first responses to their parent and associate committees (TC97 and TC95, respectively) in their attempt to grapple with these new application areas and to set the stage for the standardization required to obtain the maximum benefit from the new technologies.

There was major representation to the ISO committees from various countries reflecting both their administrations and also particular Study Groups of the CCITT. I was privileged to represent the ISO at the seventh plenary along with a number of other experts elected by 97/6 for this specific area of activity. Several meetings have been held concerning the interaction of ISO and CCITT, as well as future structuring of ISO and IEC[3], as they relate to each other, and of TC95 and also of TC97, insofar as it reflects overlap of activity in these two committees brought on by the new technologies.

1.1 TECHNOLOGY TRENDS

Telecommunication services like the distributed information processing systems cater to users at some great distance from each other and both use intelligent terminals for some processing and control equipment as well as a telecommunications plant. The need for fast reaction interactive data processing leads to employment of new channels, many of which are digital. In order to service a large population of interactive subscribers, satellite communications provide a means of minimizing communications cost or at least making it independent of distance. Several of these new technologies beg for standards so that widely dispersed subscribers can connect and benefit from the new total systems.

1.2 IMPACT ON TARIFFS

These new services will have a major impact on tariffs. Traditionally, tariffs have been full-period, flat-rate, leased-wire services. In this situation, the subscriber rented a certain portion of the telecommunication plant and paid to be able to use it at any time and to the limit of specified characteristics of the channels. Transmission speeds, modulation rates, switching delays, and so forth affect the choice. Also, the users expect the traffic level to be extremely high, and quite stable to justify the full period investment. On the other hand, there have been usage-sensitive tariffs related to the time of connection for a telephone voice call or the number of words in a Telex message, for example. In such cases, the user buys only that portion of the telecommunication plants that he actually puts to use for the message or transaction in question. He runs some risk that the system will be too busy to take his message at a given time without some delay and the carriers take the risk that the subscribers may not have traffic at all times. So, while the latter class of service may be most economical to an occasional user it probably will not be the most economical to the high usage subscriber.

1.3 NEW SERVICES AND TARIFFS

In the course of the last five years another kind of tariff has emerged - that which superimposes a use-sensitive charge on the standard flat charge based upon channel characteristics. This probably has economic benefit for a certain traffic level in some kinds of flexible systems and more data should be analyzed in order to set the right balance between the flat and the usage-sensitive factors in these tariffs. At any rate, the user should have access to the three kinds of service so that he can choose the best conditions for his application.

Two major premises emerge from the above situation. The first is that a new tariffing world has appeared and more attention must be paid to the technical content of the transmission plant being rented and the services being offered by the common carriers on one hand and their benefits to users on the other. The second premise is that these tariffs are becoming more complicated and therefore need to be re-expressed in terms of technical parameters; expressed not as single elements, such as so many amperes or so many boards, but rather in terms of complex factors, such as mixtures of delayed time, turnaround time, jitter, phase delay, singly and in combination with other parameters.

On that note, the importance of technical standards to our international base becomes the theme of our presentation today. But first, I should add a third premise: because the above factors are so user-related, participation by these users in standards writing becomes highly significant.

1.4 MAJOR TESTS

Standards close to the user are written by the ISO committees. Those standards which address safety and environment are in the purview of the IEC and users who frequently participate in ISO and IEC. However, these users are also attracted to the CCITT as well, since the CCITT contemplates much work in new end-to-end communication services. We have seen users trying to participate in writing the various standards to a much higher degree in the last three or four years. ISO committee TC154 deals with documents that are passed between users and reflect upon the software technology, in particular that of data processing systems.

The interaction of data processing and telecommunications systems brings up safety and environmental interference problems that must be catered to. For instance, a diathermy machine and a diagnostic processor should be able to operate in the same doctor's office.

Because of that background we will address the major standards that are going to be established in the future, their development, and the relationship of standards certification and regulation. Also, we will look at how the three major standard bodies (ISO, IEC and CCITT) work together and the impact that these have on trade.

2. FUTURE STANDARDS

2.1 SYSTEMS CHARACTERISTICS

Major standards of the future will involve system characteristics of available equipment services. "Services", in this sense, means doing the user's job for him by performing an application. There are times where I will also use the term services to indicate a service provided by a telecommunication carrier in which no equipment is purchased by the user. Instead he buys use time on various kinds of equipment without operating or controlling the apparatus and gets the necessary benefit from having been connected. In a similar way, an information processing service can take time cards from several workers and produce a payroll, a tax report and all the mechanization in between. It is done by the service provider, not by the applicant. The system characteristics then permit users to compose a system or to select a complete system from the marketplace.

2.2 SERVICE REQUIREMENTS

The secondary use of standards will be to define some services desired, either in the form of complete specifications or in other cases, statements of required improvements needed in existing services. A third area deals with the ability for a user to compose his system from a number of elements by a variety of manufacturers or for a manufacturer to penetrate the total systems market by only supplying one component.

2.3 PROTOCOLS

These standards then involve various interfaces between modules defined by an architectural model. Various protocols exist for communicating across those interfaces from one module to another and the ability to connect certain data processing equipment to networks of telecommunications channels with defined performance characteristics. There obviously are many other standards that are already in industry and will continually get upgraded as the technology in their specific areas improves. One type of improvement is the growth over the last four or five years of attempts at equalization applied through the use of microprocessors in modems. The need for conditioning of fixed and leased communication channels and the differences between leased and public switched channels is disappearing. In fact, even when leased channels are to be used the reduction in conditioning will reduce the cost of those tariffs, and for very long circuits will show that the more expensive and intelligent modem is a worthwhile investment instead of expensive line conditioning.

3. OBJECTIVES OF FUTURE STANDARDS

3.1 TOOL SELECTION

As mentioned in the opening, the objectives for these future standards are to let the users and system architects select the best tools to accomplish their several missions. We found long ago there is no single architecture in the data processing industry that satisfies all data processing applications. The same thing is true on an even grander scale for telecommunications distributed systems. It is therefore necessary for a user to make use of a variety of data processing offerings of different MIP rates (the number of instructions per unit time - a measure of processing throughput comparing alternative communication channels). We are talking in terms of an all-digital channel and a number of other features for interactive paging displays such as the refresh rate of a CRT screen.

3.2 RATIONAL PRICING

Only when all parties can play at the modeling game which would include a variety of data processing offerings or communication channel offerings and interconnection services can the economic factors in the marketplace provide the incentive for cost reduction, and avoid offerings which are not cost competitive. The long range effect of this is the clear benefit of driving costs down as a function of time, with users benefiting as more applications are found for the system.

3.3 MARKET FORECASTING

Aside from the economic aspects, design standards give suppliers much more confidence to compete in the total world marketplace where many communications options for business exist.

3.4 INTERCONNECTIVITY

Standards put forth through CCITT and ISO are the means of achieving worldwide connectivity. Of course, many of these standards are voluntary, and no national administration need adopt any of these standards. Each administration may work to any national standards, as long as the traffic never crosses his national boundary. All administration must abide by CCITT recommendations for international traffic, and any two (or more) administrations may by common agreement select options within approved CCITT recommendations or may anticipate or recommend a deviation for their mutual traffic. Given the prestige of an approved international standard, many national bodies automatically adopt and call for these international standards in their national procurements,and some national standards bodies (member bodies of ISO) actually apply it when they back their endorsement by internal use of the international standard.

4. WHO DEVELOPS STANDARDS

4.1 USERS

Now, who is involved in these developments? Presently, there are many huge users of dedicated communication systems such as the IATA, ICAO, SWIFT, General Motors (to name one single industrial user) and many other similar user groups.

4.2 GOVERNMENTS

Also involved are various governments and their role is quite complicated. They sometimes appear as a regulator, sometimes as a common carrier and as a service provider, and sometimes as a military operator or consumer.

4.3 REGIONAL INTERESTS

We see European Computer Manufacturers Association (ECMA)[3] and various common market agencies attempting to provide regional standards. We expect that regional standardization will happen more frequently and that the Pacific Telecommunications Council can be one that is a spokesman if not the standards developer for its region.

4.4 EQUIPMENT SUPPLIERS

We also naturally expect that the equipment manufacturers, including the software suppliers, will continue to be active in the standards writing activities. Their interest is in trying to limit the user to things that are feasible and technically possible, to develop items for interconnection so that their markets can broaden, and to prevent misapplication in certification procedures for regulatory activities.

4.5 ACADEMIC AND PROFESSIONAL INTEREST

In addition, we find that there have been a number of academic and professional experts entering the field of standards and we expect this will continue. Based upon some of the recent activities within the IEEE at least, we expect to see a more dominant role taken by this community. We recognize the academic contribution as far back as 1960 when they developed ALGOL. IEEE groups are active now in various national and international committees concerned with microprocessors and in new program languages.

5. PRINCIPAL STANDARDS WRITING BODIES

5.1 INTERNATIONAL

The CCITT and the CCIR are technical advisor agencies of the International Telecommunications Union, an agency of the United Nations which offers membership opportunities for any of the U.N. members. Most study groups have twenty to sixty national administrations sending experts, providing various rapporteurs and a chairman. The ISO and IEC are both voluntary participation agencies of the U.N. in the area of cultural exchange. Member bodies represent each country in the ISO: for the U.S. it is ANSI[4]; the Standards Association of Australia represents that country, and so on. The IEC was initially organized to define electrical fundamental parameters to achieve worldwide uniformity in weights and measures, etc. "National Committees" have been developed in each country and they form the basis of representation in the IEC.

Even though ISO and IEC have different structures and different origins, their work has become of much more common interest as the technologies have grown and fused together. For a time, there was a small conflict between IEC committees TC53 and TC97 but this was later sorted out to alleviate duplication. At one time there was safety activity in each of ISO and IEC and this led to agreements which have assigned the writing of all safety standards of interest to ISO and IEC to IEC TC74. Other than safety, electromagnetic interference, and structural hardware components, most international standards for total distributed data processing systems are done in ISO/TC97 and TC95.

The CCITT's seventh plenary, as mentioned, will have produced a new program of work in the form of a series of questions. These programs are assigned to particular Study Groups. It will have also produced a series of "recommendations" which are, in effect, potential international and national standards. They have also discussed organizational matters which deal with the changing technology and how CCITT can most efficiently work in view of those changes. It is clear that organization must be influenced by the growing technology but there are delicate technical and political spheres that need to be considered along with the absolute technological changes. Maintenance of old recommendations in the CCITT, continuance of proper leadership, the need for a highly experienced study group chairman and the number of vice chairmen to handle the work assigned to the study group are as important as the technical work.

Similar statements can be made relative to ISO. At recent meetings (1979) in Madrid of ISO TC97, the work of implementing the architectural model was divided between subcommittees 6 and 16, and a new study group for encryption was created. In a contiguously timed meeting of TC95, a new committee to handle facsimile office machinery and services related thereto was established as a separate entity from the subcommittee addressing other office machines. In joint meetings between these two committees, consideration was given in ad hoc bodies empowered to continue studies on the relationship between the two TCs and the possible conflict of their subcommittees in the work assigned.

TC97 adopted a series of resolutions that attempted to improve the interworking between itself (and ISO in general) and the Study Groups of CCITT. This is still under discussion and the importance here is that the experts seem to find a way to cooperate without much trouble. Formal structuring of the finished documentation for which each body is responsible must recognize the nature of their origin of authority, namely, the treaty nature of the ITU and the nontreaty nature of ISO and IEC. In spite of those differences, we believe there can be more joint meetings which will be beneficial and that these meetings should have the power to act, if they are to utilize effectively power which was previously given by those who hold the authority now, and that parochial constraints would have to be yielded in order for this to happen on a timely basis.

5.2 NATIONAL LEVEL

At the national level we have a similar problem as the respective national bodies prepare to meet in the international arena with their peers. More user participation must be made possible by each administration of the CCITT, member body of ISO, and National Committee of the IEC. We further urge that the International Secretariats study their own operating procedures with a view to harmonizing how they came about and how they should be employed in the future, with a view toward making documentation homogeneous in style and structure. The benefit of that work will filter down to the national levels.

5.3 REGIONAL LEVEL

Some regions of the world have problems common to each other, but quite different from other parts of the world. These differences may be environmental (tropical versus arctic), geographic (served by a convenient common, communication/transportation system), economic (possessing a common natural resource), demographic (common language) or military/political (common self defense). These commonalities uniquely affect the priorities of the standards programs of interest to each member of the region. By expressing their needs as a mutual and total interest instead of terms of self interest, they have more "clout" in international arenas.

ECMA and OPEC are two such examples of regional influence. The Arab Telecommunications Union is another. PTC can achieve the same level of effectiveness.

6. REGULATION AND CERTIFICATION

6.1 MANDATORY VERSUS VOLUNTARY STANDARDS

I would now like to turn to a consideration of the impact of standards on regulation and certification. In this connection we have to distinguish between voluntary and mandatory standards. We believe that standards should be achieved by independent standards writers representing the using, producing, regulatory, and consumer branches of the public, and that the government should take part in cooperation with one or more of these particular constituencies, rather than as a dominating, overriding agency. In this way technological progress works its way into the standards as early as possible. The more effort to produce a mandatory standard, the earlier people will lock positions protecting their economic structures and agreement in fewer standards will result. This is not to say that there is no place for a mandatory standard. Mandatory application of voluntary standards I believe is the best of the two worlds.

We must have mandatory standarization with regard to environmental protection and safety. There can be no compromises beyond a certain limit. When two bodies interconnect there must be a rigorous agreement, be it voluntary or mandatory; there can be no frivolous optional choices by any one or several of the participants. If there is a price to be put on the product of service such as a tariff, there can be no equivocation as to the content of what is being offered. Thus, there are fairly rigorous standards, be they called mandatory or not, that are required for interface, for pricing, and for protection. To go further than that will stifle innovation, create an economic discrimination against some to the benefit of others - an inappropriate benefit, by the way.

We should look at this point in the light of complaint that standards writing is too slow. I would never want to give up the goal of achieving standards faster, but I would not want to compromise a single degree of education that comes from the interchange during the writing process nor with the attempt to get a maximum concensus of all interest. Broad consensus assures that the standard would be applied at the earliest possible time with the most available products and in the most effective and diligent way.

6.2 STANDARDS PLANNING

Over the past few years there has been a new element injected into the standards writing process, namely that of standards planning. It is hardly off the ground on an international basis and is running into much opposition. There are no official bodies created to do planning. The nearest to organization that we know of in the international arena is the meeting of several Study Group chairmen under the control of the CCITT Central Secretariat; the projects in TC97/16 for the architectural model under its control; and the occasional subcommittee (e.g., 97/6) "Heads of Delegation and Convenors" meetings. In the U.S., ANSI has an X3/SPARC (Systems Planning and Requirement Committee) that should serve as a jumping off point for exercising some planning and some control of standards. SPARC receives all proposals for new standards projects. It measures each against established criteria: "Is there a proven need for the Standard? Who and how much will benefit from the Standard when it is finished? Is there anyone else working this topic or who plans to produce such a Standard? When will the project be finished? Is it technically feasible?" If all criteria are positive, then SPARC recommends the project be instituted, manned, and funded. SPARC monitors the work and reviews the final draft before balloting for approval takes place. When a standard product meets these criteria and then doesn't make progress, there should be a tracing action to find a reason for the lack of progress and to correct it. SPARC does such things and we advocate that that principle be adopted as early as possible in the organizational structures of all international standards writing bodies.

Gross modeling has been injected in TC97. This is another tool that aids in the interrelationship of many standards writing activities and incorporates a method of checking whether the result is beneficial or not.

6.3 USER PARTICIPATION

Finally, while we claim that enough expertise exists to do all that is needed, it is necessary to make sure that it is applied in a timely way to the most urgent of the topics available. Planning coordnation between several standards writing bodies by organization and scheduling and the use of architectural models therefore will and must be the answer to the complaints that it takes too long to get a standard. The users must have the privilege of participating but in that privilege is contained a responsibility to put forth reasonable requirements, economic trade-off considerations, the ability to support the requested standards, distinction between procurement, design, certification and interchange parameters, and to insure that there be alternatives. They must indicate relative to the economics what variety of alternatives they desire.

6.4 APPROACHES TO STANDARDS AND CERTIFICATION

The design standard that comes from the work above is and must be the basis for certification standards and for regulation. The technical specification must come first and be achieved without the political pressure that always accompanies certification and regulation. The economics, the politics, and the opportunity for discrimination would distort the technical basis for a regulation if we do not try to separate the two factors. Certification must also be separated because the limits that apply to a certain parameter when used as a design goal may differ greatly from those used when a requirement for minimum performance is wanted.

6.5 DESIGN STANDARDS DIFFER FROM CERTIFICATION CRITERIA

Consider the need for standards relating to magnetic tape. One standard is needed to determine whether the new tape being procured is satisfactory. By noting the signal level when the tape is recorded and played back using a calibrated reference read-record head, and at the same time noting background noise, the buyer establishes whether the tape equals or exceeds the standards, and he can then accept delivery of a passing tape. Now as he uses the tape (recording, reading, erasing many times) there will be wear of the tape's magnetic coating and the signal level will gradually diminish. When should the user of the tape discard it? He needs an interchange standard. If only the initial characteristics standard exists, the tape has no predictable service life. System designers need an interchange standard for utility planning purposes. Certifiers use the procurement specification for control of tape production and sale, not for life-cycle performance.

These are two independent requirements and should be treated as two separate technical bases for two different documents. One is certification and the other a procurement regulation. Certification should assure the user that an independent agency has taken steps to insure that whatever the source, he, the ultimate recipient (the user) is protected by criteria established by the certification agency. This kind of statement does not preclude self certification. In fact, it should encourage self certification.

Manufacturers should be granted the opportunity of self certification and users should be granted the savings in cost by not requiring 100% of each item produced to be tested for certification levels. Any abuse of these privileges either would cause the vendor to be thrown out of the market or have his cost increased by requiring 100% compliance and testing. Again, regulation should be for the protection of all parties, not one, and should form the basis for interchange between the different communities, users, producers, and so forth, and also for establishing producer-to-user tariffs. Certification should also stabilize performance parameters so that users' and producers' investments can be considered stable because of regulations holding to specifications. We may conclude from these points that the voluntary development of technical standards and recommendations forms a cornerstone for users on which to specify their procurements; a base for producers to specify the designs of their products which will eventually reach the market place; and which eventually will form the basis of development of proper tariffs, proper certification procedures, and regulations that will control the interworking of all of these products and services.

6.6 NO NEW EXPERTISE NEEDED

No new expertise need be brought into the arena in order to generate the technical standards that are now being thought of in relation to new technology. Nevertheless, as new technology produces a need for new standards, attention must be paid by the management of the standards writing bodies to reorganize when necessary to fit the technology, to balance their workload, and to avoid duplication or gaps in the programs of work. One of the major characteristics in the technological revolution leading to today's presentation has been the disappearance of a line of demarcation between the computing industry and the communications industry. Both industries have invaded, by virtue of available technology, the marketing sphere of the other until there is now more common ground than there is unique ground. Because of this, these two industries are competitors, friendly competitors, and competitors who cannot go it entirely alone but need each other's help over the next decade or two, at least, to round out the full system.

We are therefore deeply entered on an era where mutual cooperation is paramount. It is under these circumstances that improved relationships and improved means of working together must be put forward. Meetings are continually needed to improve the formal workings as well as the informal workings at the Secretariat level, at the national levels, and finally amongst experts. If necessary, perhaps some higher level at the U.N. might also be called upon. I would consider that as a last resort, probably not capable of producing the necessary results if it cannot be achieved at the other levels. The punch line is economics and it is my belief that both industries can grow in an atmosphere of cooperation at a much more rapid rate than if their main objective is to swallow and eliminate the other.

The number of potential applications far exceed those that are being put to practice today and most rapid growth will occur when the two groups work together. This has a direct impact on trade. Each industry, when it introduces a new product or service, increases the marketplace of the others. Conversely, when either attempts to freeze the other out of that market area, each will fail to realize full business potential. Certification, when it is used to achieve commonality and interchange and when it is used to achieve testing for support of criteria of environment and safety, benefits the user and does not stifle trade. Regulation can promote interchange, but like improper use of certification or even technical criteria, it also can stifle rather than enhance and encourage. It is up to all communities to utilize these tools for the public good and not for parochial constraint to gain an advantage that isn't achieved on technical merit or economic efficiency. We look forward to seeing the rapid growth of the Pacific area by virtue of telecommunications linking the businesses of all parts of the basin and adoption of appropriate standards which greatly encourage the free and prolific use of the benefits available to us.

Thank you.

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[3] ECMA
114 rue du Rhône
CH 1204 Genève 20
Switzerland

[4] ANSI/USNC-IEC/USA member body for ISO
1430 Broadway
New York, NY 100218

INTERNATIONAL COOPERATION IN THE DEVELOPMENT OF TELECOMMUNICATIONS STANDARDS

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Abstract

This paper on Telecommunications Standards stresses the importance of the total information system, the systems approach to standards development, and the need for close international cooperation between international standards organizations.

When I was asked to participate in this session on the "Future Direction of Telecommunications Standards," I accepted because I believe this is a very important and timely subject for international discussion. The Pacific Telecommunications Conference is to be commended for providing a forum which brings an international focus to the area of telecommunications standards at a time when the scope and complexity of these activities are greatly increasing.

I have, for some time, thought that attempting to predict the direction of standards development in areas of high technology is like predicting the weather -- regardless if you're right or wrong, it changes and you have to start forecasting all over again. However, I believe that the future direction of telecommunications standards will be influenced by three important factors.

1. The assimilation of telecommunications into information processing systems to meet an ever-broadening set of user information requirements and applications.
2. The establishment and use of a systems approach in the development of telecommunications and information processing standards.
3. The level of international cooperation between major international standards organizations such as the CCITT and the ISO.

When examining the first of these factors, it becomes evident that information systems of the future will be much more extensive in their application and will require that the user have the ability to interrelate a large number of data bases, integrate a variety of information sources, and respond to a broad spectrum of information requests. These systems will be broad in scope and will require the capability to receive, process, store, retrieve and transmit information in the forms of data, text, fax, images, and be able to handle other specialized requirements such as encryption.

Such an extension application of information systems will only be possible through an assimilation of telecommunications capability. Here I think it's important to stress the term "assimilation" because the concept that telecommunications will be part of a larger structure is important when assessing the proper direction of telecommunications standards.

I feel that a major consideration of standards development in such a system is to insure that the basic relationships required are defined without interfering with or limiting the major functions of the system and without denying the user the necessary options for facility selection, and the ability to make the cost tradeoff decisions involved.

I think it's important to stress two other important factors that should be taken into consideration in any standards development effort.

1. The value of the investment that the users have in their present systems.
2. The importance of providing wherever possible options which permit the user to customize his applications in accordance with his own unique requirements.

It is important that we do not arbitrarily impact these factors and that we insure that the needs of the user and the realities of the user situation are taken into consideration.

These are a very complex set of objectives which present a new challenge to those of us involved in the development of telecommunication standards. In essence, these standards must recognize the dynamics of the system of which they are a part and not stifle innovation or deny the user the benefits of greater function, increased cost performance or technological advancement.

Certainly the development of such standards is not an easy task but if we are to meet the future information systems needs of business, government and the public, it is essential that these standards have these characteristics.

A significant effort in this direction occurred at the 1977 Plenary of TC/97 which is the Technical Committee of ISO responsible for computers and information processing.

A new subcommittee was established to investigate the need for standardization in the area of open systems, as it relates to system interconnection. This included the study of the structure and nature of the standards required for exchange and interchange of user tasks, system control and status information.

The title of the new committee was "Open Systems Interconnection" more commonly referred to as OSI. Its initial objective was to develop a schematic model and to identify the interfaces and protocols to be considered for standardization.

The outcome of the initial phase of the OSI program was the development of the ISO Reference Model for OSI which is sometimes referred to as the seven layer model.

This model was presented to the 1979 Plenary of TC/97 in Madrid, along with a group of specific projects for standardization within the framework of the OSI model. These projects were approved and work is now in progress internationally.

The OSI program is a complex and massive undertaking for those of us involved in the voluntary standards system, and I believe the speed at which this program has moved and the level of agreement which has been accomplished to date is unparalleled in international standards work. The model has also become an important element in the telecommunications standards interests of the CCITT, the European Computer Manufacturers Association (ECMA), the European Economic Community, and numerous national standards organizations and governmental agencies.

But the importance of the OSI program goes beyond the individual standards that will be produced, some of which might not find universal agreement or implementation. In my mind, the major significance of this program is that it resulted from a recognition that a systems approach to standardization is required. That it is necessary to establish a framework in which individual standards development efforts can be planned and developed within a total system. A systems approach not only helps establish a standards direction that is consistent with the overall objectives of a system but allows for multiple development efforts to be integrated into a cohesive structure.

A total systems understanding will not only insure the feasibility and practicality of a particular standard, but it will also help insure that a standard for one segment of the system does not have a detrimental effect on any other segment of the total system. It will also help insure that we do not restrict internal systems design options or inhibit innovation.

The third factor of importance is that of international cooperation. There are two primary international organizations involved in the development of telecommunications standards. The International Telephone & Telegraph Consultative Committee (CCITT) of the ITU and the International Organization for Standardization (ISO). These two organizations have approached the subject of telecommunications standards from different directions. The CCITT from the perspective of communications transmission and the ISO from the perspective of information systems.

However, over the last few years because of a trend towards common technology and increasing areas of common interest there has been greater overlap between these two organizations in their standards programs. This has been highlighted by activities in both organizations in such areas as network protocols, open systems interconnection, codes, text, and facsimile.

This commonality gives rise to an increasing possibility for duplication of effort. This is of concern to all of us involved in standardization for the following reasons.

1. The talent that can be devoted to the development of telecommunications and information processing standards is a limited and precious resource which must not be diluted through duplication of standards activities.
2. The development of international standards is an expensive process and one that cannot afford the luxury of duplication.
3. Duplication also increases the possibility for publication of conflicting standards, which are detrimental to all objectives.

For these reasons, a major effort is being made to promote cooperation between the ISO and CCITT and all other international organizations involved in the development of telecommunications standards. I fully recognize that these organizations are quite different in their legal structure, their standards process, and their rules for membership. But they also have some very important common characteristics.

1. Their work is internationally accepted by business, governments, and users.
2. They have a significant number of common members and participants in their standards activities.
3. The user community looks to both organizations for direction on future development of international telecommunications standards.
4. Both organizations have an already established liaison relationship.

In September of last year, the ISO sponsored an informal meeting between key members of both organizations to discuss international cooperation. That meeting, I believe, was a frank and thorough discussion of the differences, the objectives, the responsibilities and ideas by which close cooperation could be established between the two organizations. These ideas included:

1. The establishment of a mechanism by which there can be a joint review of the appropriate standard development programs of each organization which would insure an understanding as well as an identification of possible areas of duplication or conflicting interest.
2. Wherever possible and without interference with the overall charter of either organization, the establishment of an interworking capability for the development of standards in areas of common interest.
3. The establishment of a cooperative liaison between the appropriate committees or organizations at the national level.

The degree to which these ideas can be instituted will depend on the results of future dialogues between ISO and CCITT.

However, a great step forward would be achieved if these ideas could be accepted at least in spirit by the technical committees of the two organizations, and I think in that regard all of us who work in international standardization have a responsibility to promote this kind of cooperation. I believe it is extremely essential that we achieve a spirit of close cooperation if we are to have a meaningful and useful international standards program in the areas of telecommunications and information processing.

In my talk, I have stressed what I believe are three very fundamental and important factors involved in the setting of the future direction of telecommunications and information processing standards. My comments, I believe, are based on a realistic assessment of the present standards environment, and I ask each of you to evaluate these needs in the framework of your own experiences.

In closing, I would like to again thank the Pacific Telecommuniations Conference for giving me the opportunity to share some of my thoughts with you and for sponsoring this international discussion. I look forward tb discussing some of these issues further with my colleagues and in answering any questions you might have.

Ladies and Gentlemen, thank you very much.

THE IEC AND STANDARDIZATION IN ELECTRONICS
THE PAST, PRESENT AND FUTURE

FOR THE PACIFIC TELECOMMUNICATIONS CONFERENCE

By

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1. INTRODUCTION

The phenomenal growth in electronics in recent years, has been made possible, to a major extent, by international co-operation and agreement on standards. To this end, a number of international congresses were held at the end of the 19th century and the beginning of the 20th century. Looking back from today's situation, it is hard to appreciate the lack of common agreement, at that time, for even the most fundamental electrical units. When the First International Electrical Congress was held in Paris in 1881, there extested for example:

12 different units of electromotive force

10 different units of electric current

15 different units of resistance.

This Congress led to international agreements concerning the ohm, the volt and the ampere, and relating to each other according to "Ohms Law". From modest beginnings, such as this has developed the vast international trade in electrical engineering and electronics that has become an accepted part of modern life.

At the International Electrical Congress held in Saint Louis (U.S.A.) in 1904, a resolution was passed by the Chamber of Government delegates, on a motion proposed by Col. R.E.B. Crompton (U.K.) that was in part as follows:

> "that steps should be taken to secure the co-operation of the Technical Societies of the world by the appointment of a representative Commission to consider questions of the standardization of the nomenclature of electrical apparatus and machinery".

As a result of this decision, the 'International Electrotechnical Commission' (IEC) came into being at a constitutive meeting held in London in 1906. Since then, the IEC has been the official permanent body for electrotechnical standardization and met in 1908 in London, 1911 in Turin and 1913 in Berlin. Meetings were then interrupted by the first world war but again resumed in 1919 in London and held 8 General Assemblies up until the second world war. Meetings again resumed in 1947 in Lucerne and have been held annually throughout the world since then.

The object of the Commission is to facilitate the co-ordination and unification of National Electrotechnical standards and to co-ordinate the activities of other international organizations in this field, mainly with the intention of facilitating international trade. The Central Office, or administrative body of the organization, was originally established in London, where it was to remain until transferred to Geneva in 1947.

In the early years, the attention of the IEC was naturally mainly directed to heavy current side of the electrical industry. However, attention was also paid to the important subjects of nomenclature, units, letter and graphical symbols. Much of this early work passed so far into the framework of electrical engineering as to be almost forgotten, surely a great tribute to these pioneering efforts.

During the 1920's radio receivers became available to the general public in large numbers. The need for standardization soon became apparent, to ensure the safety of this new and complex apparatus and to facilitate the replacement of components, particularly the electronic tubes. The IEC, therefore, decided in 1927 to set up Advisory Committee No. 12 "Radio Communications" the term Advisory Committee having since become Technical Committee. From this modest beginning the work on electronics has spread into the activities of some sixty committees today.

2. ORGANIZATION

The IEC works through "National Committees", one for each member country. Any self-governing country, desiring to participate in the work of the IEC, may form its own representative committee and apply for membership. This committee, when it is accepted, is known as the National Committee of that particular country. The National Committee is expected to be as representative as possible of all electrical interests including, manufacturers, end users, government, technical and scientific organizations. At the beginning of this year, 1980, there were National Committees in forty-three (43) countries representing most of the world's population and all the major exporting and importing countries.

The supreme body of the IEC is the "Council", composed of the presidents of the National Committees or their representatives.

Immediately after the Council come the "Committee of Action" which is composed of the representatives of twelve (12) countries, elected periodically by the Council. The function of the Committee of Action is to deal with the technical administration of the IEC and other business in between meetings of Council. The Council normally meets once a year.

The technical work of the Commission is carried out through Technical Committees, each one dealing with a clearly defined subject. The terms of reference, or "scope", of the Committee is agreed to at the time of its formation and is subject to approval of the Council. Such approval is also required, should it be desired to amend the scope.

The Council considers the setting up of a New Technical Committee when, one or more National Committees propose it, all National Committees having been consulted by the Central Office and more than 1/3 (one-third) of National Committees are in favour and the Committee of Action has reviewed the proposal and has decided to submit it to the Council for formal approval. Alternatively, the Committee of Action may itself originate the proposal and request the approval of the Council.

Technical Committees may be sub-divided into sub-committees, each dealing with a specific part of the scope of its parent committee as shown in Figure 1. Each Technical Committee and subcommittee has a technical 'Secretariat', held by one of the National Committees, which is responsible for seeing that the work proceeds actively through the Secretary of the Committee.

A small administrative staff operates at the IEC 'Central Office' in Geneva. The Central Office is responsible for carrying out the decisions of Council and the Committee of Action, the reproduction and circulation of all working documents, publication of IEC recommendations when approved, the organization of meetings and liaison with other international bodies. Its costs are met by contributions from the National Committees and the sale of publications.

3. WORKING PROCEDURES

The nucleus for the activities of a Technical Committee is its Secretariat since the Secretariat is responsible for the preparation of all the basic documents which are required for achieving international standardization on a given subject. The 'General Directives' for the work of the IEC explains that "The Secretariat normally first collects information on existing national and international work that has been done on the subject under consideration." Taking into account the information received, the Secretariat then prepares a preliminary draft for consideration by the National Committees. But here, the Secretariat faces one of the basic dilemmas of standardization.

When work on a given subject matter is well advanced, before international standardization starts, there will be a wealth of information available to the Secretariat and very likely existing national standards in some countries. Inevitably, there will be certain differences in these standards that may lead to a conflict of interest where attempts are made to establish international agreement. Alternatively, if the subject matter is very new it is likely that no standards or recommendation exist at all and probably there is insufficient information available to prepare a reasonable initial draft for consideration.

The present trend is to start standardization work at an early stage during the development of new systems or technology. It is then usual for committees to establish a Preliminary Working Group to collect and generate the information required to write the preliminary and subsequent draft of the documents. The working group comprises a selection of specialists, in the given field, appointed by a restricted number of National Committees whose countries possess the necessary expertise. The role of the Working Groups, however, remain that of assisting the Secretariat of its parent committee in carrying out a particular part of its work.

The working procedure, on a new subject, is illustrated in Figure 2. Following authorization of the work by the Committee of Action, the Secretariat collects the information needed to prepare a draft Secretariat document, based on existing standards, publications and work being done on related subjects in other committees. When there is insufficient information available it may be decided to propose to National Committees that a Preparatory Working Group should be set up and to ask which countries wish to nominate an expert on the subject. The Working Group then has the responsibility to help generate the material needed for a Secretariat document. At this time, the Committee Chairman acts as an advisor to the Secretary.

When the Secretariat draft is ready, it is sent to the Central Office for circulation to all National Committees. Any comments, on the document from National Committees are also sent to the Central Office for general circulation. The Secretariat document and comments are then discussed at the next committee meeting. Delegates to the committee meeting represent their respective National Committees and, in the discussion, present the countries' collective view, not personal opinions. As a result of the discussion, a consensus may be reached to submit the document for formal approval and publication or, if significant amendments are required, to refer

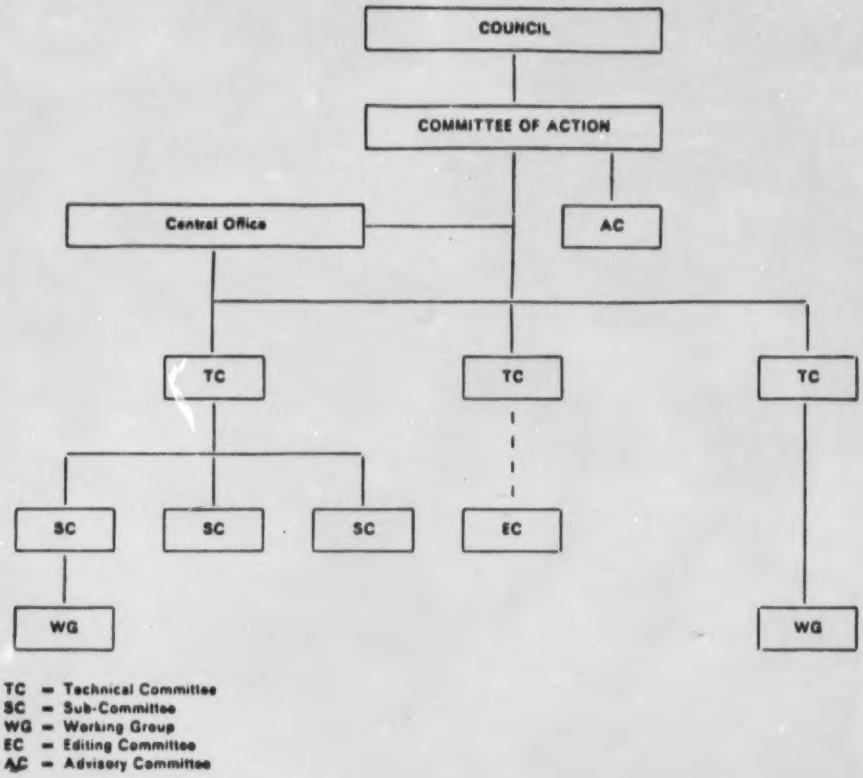
COUNCIL
COMMITTEE OF ACTION
Central Office
AC
TC
TC
TC
SC
SC
SC
EC
WG
WG
TC – Technical Committee
SC – Sub-Committee
WG – Working Group
EC – Editing Committee
AC – Advisory Committee

Fig. 1 Organisation

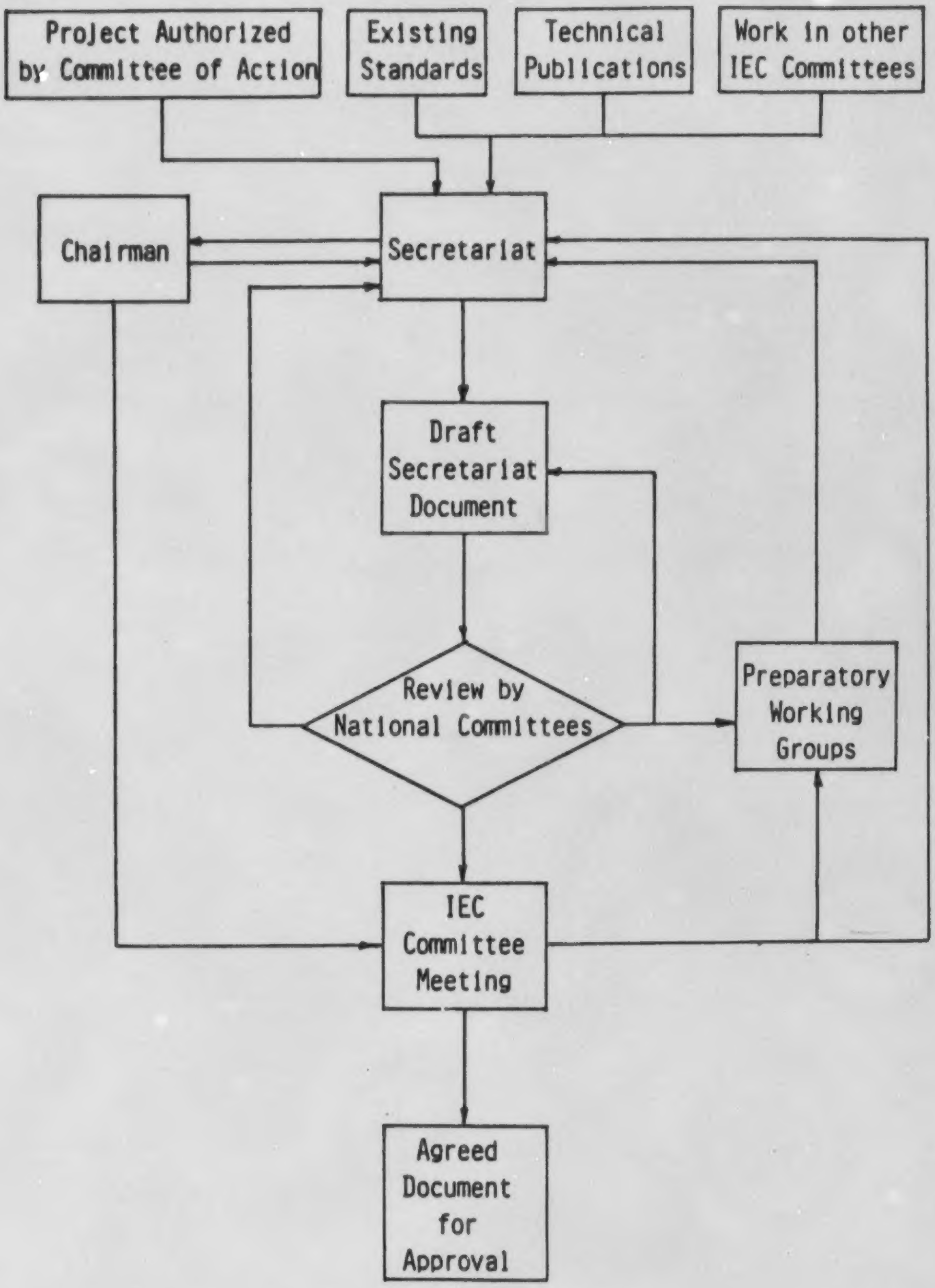
Project Authorized by Committee of Action
Existing Standards
Technical Publications
Work in other IEC Committees
Chairman
Secretariat
Draft Secretariat Document
Review by National Committees
Preparatory Working Groups
IEC Committee Meeting
Agreed Document for Approval

Fig. 2 Processing Working Documents

the matter back to the Secretariat or Working Group for further study. A revised Secretariat document is then prepared and the review and discussion procedure repeated.

The methods by which IEC drafts are approved for Publication as a recommended standard are illustrated in Figure 3. When a Technical Committee is of the opinion that a certain subject has been considered, either by itself or by a sub-committee, to such an extent that sufficient agreement has been reached for the resulting draft to be issued in an IEC Publication, the Committee of Action is informed accordingly and a bilingual (French and English) draft is submitted for approval under the "Six Months' Rule". This is the normal procedure.

However, when reasonably good agreement has been reached, but insufficiently good to permit the direct circulation of a Six Months' Rule draft, the Technical Committee may decide to use the Accelerated Procedure. This implies the circulation of a bilingual Secretariat draft to the National Committees for discussion. If there are no major objections to the draft within a specified time, usually three months, the Secretary of the Technical Committee, in consultation with the Chairman, may ask the Central Office to issue a formal notice that the Secretariat draft is now considered to be submitted for approval under the Six Months' Rule, without the circulation of a further document.

The object of this procedure is to avoid having to wait until the next committee meeting before the decision is made to submit the draft for approval.

The use of the above procedure implies that the Chairman and Secretary of the Technical Committee consider there to be a good probability that the draft will be accepted. If, on the contrary, there is insufficient support from National Committees, the draft is put on the agenda of the next meeting and is discussed in the usual way as a Secretariat draft.

When a document is circulated under the Six Months' Rule, National Committees receive a voting paper to be returned with their vote and comments, if any, before the close of the six months' period. The Central Office then sends the results of the voting, together with any comments, to the Chairman and Secretary of the relevant committee for consideration. A report is then circulated which shows, the results of the voting, reproduces the texts of the comments received, gives the observations of the Secretariat on those comments and includes the conclusions of the Chairman.

If not more than one-fifth (20%) of the votes are against the draft and if only comments of an editorial nature are received, the document may be published after final editing. If on the other hand, the results of the voting show that the draft has not been accepted but comments of basic importance have been received, the Chairman of the Technical Committee has the right to decide on:

(a) publication without amendment, provided he considers there is no prospect of better agreement.

(b) accepting the amendments and having the relevant revised texts circulated under the Two Months' Procedure.

(c) referring the draft back to the Committee for further consideration.

When alternative (b) is selected, National Committees vote on the Two Months' Procedure document and indicate their preference for either the amended or original text.

The proceeding information describes the most important stages in the preparation of an IEC publication.

4. WORK OF THE IEC IN ELECTRONICS UP TO THE PRESENT TIME

During 1979 (80 figure not available as yet) approximately 35,000 pages of working documents were issued in connection with the preparation of future IEC standards. Nearly 7,000 pages of drafts were submitted to National Committees for approval and the cumulative sum of pages in IEC Publications reached 48,600. The numbers tend to progressively increase each year.

Since a major proportion of this material results from the activities of committees working in the electronics field, it would be a formidable task to provide a meaningful description of all the work in progress. Lists of the subjects under discussion in the various committees may be found in the current edition of the "Report of Activities".

To give a broad indication of these activities, I have tabulated the committees, of special interest to the electronics industry, in groups according to subject area. The first general interest group (Figure 4) includes Technical Committee No. 1, 'Terminology', that is responsible for the International Electrotechnical Vocabulary (I.E.V.) on which many national electrotechnical glossaries are based. The first edition of the I.E.V. was issued in 1938 but since that time it has been totally revised and published as a series of more than 40 individual sections, each dealing with a specific group of terms. The definitions are given in French, English and in some more recent chapters also in Russian. The terms themselves are given in German, Spanish, Italian, Dutch, Polish and Swedish, as well as the previously mentioned languages.

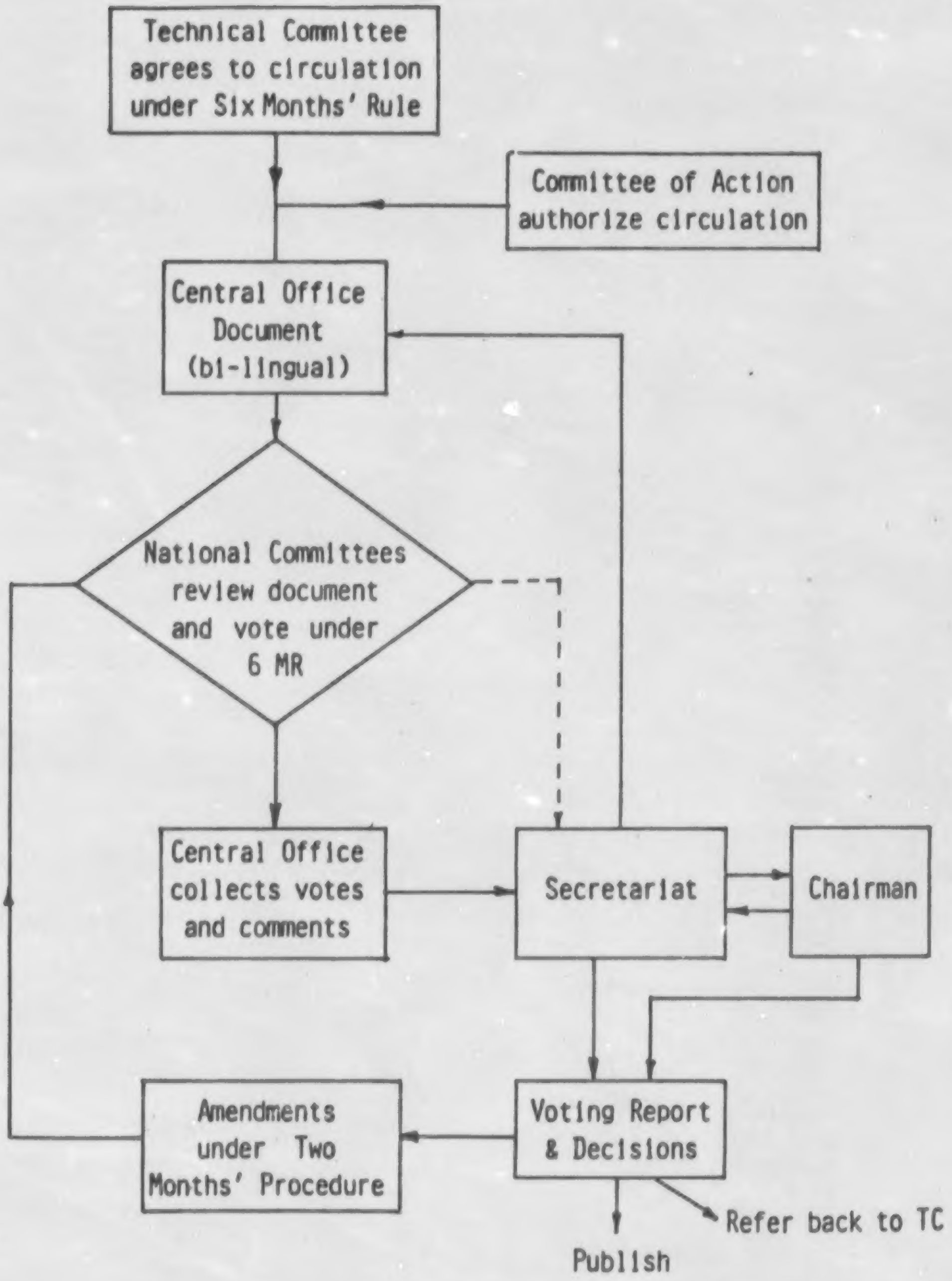
Technical Committee agrees to circulation under Six Months' Rule
Committee of Action authorize circulation
Central Office Document (bi-lingual)
National Committees review document and vote under 6 MR
Central Office collects votes and comments
Secretariat
Chairman
Amendments under Two Months' Procedure
Voting Report & Decisions
Refer back to TC
Publish

Fig. 3 Approval of IEC Drafts for Publication (normal procedure)

TC 1 - TERMINOLOGY

TC 3 - GRAPHICAL SYMBOLS

TC 13 - ELECTRICAL MEASUREMENT EQUIPMENT

TC 66 - ELECTRONIC MEASURING EQUIPMENT

- SC 66A - GENERATORS
- SC 66B - OSCILLOSCOPES
- SC 66C - BRIDGES AND METERS
- SC 66D - ANALYSING EQUIPMENT

FIG. 4 COMMITTEES OF BROAD INTEREST

TC 39 - ELECTRONIC TUBES

TC 47 - SEMICONDUCTOR DEVICES AND INTEGRATED CIRCUITS

- SC 47A - INTEGRATED CIRCUITS

TC 49 - PIEZO-ELECTRIC DEVICES FOR FREQUENCY CONTROL AND SELECTION

FIG. 5 ACTIVE COMPONENTS

TC 23 - ELECTRICAL ACCESSORIES

- SC 23C - WORLD-WIDE PLUG AND SOCKET-OUTLET SYSTEMS
- SC 23J - SWITCHES FOR APPLIANCES

TC 32 - FUSES

- SC 32B - LOW-VOLTAGE FUSES
- SC 32C - MINIATURE FUSES

TC 35 - PRIMARY CELLS AND BATTERIES

TC 40 - CAPACITORS AND RESISTORS FOR ELECTRONIC EQUIPMENT

TC 46 - CABLES, WIRES AND WAVEGUIDES FOR TELECOMMUNICATIONS EQUIPMENT

- SC 46A - RF CABLES
- SC 46B - WAVEGUIDES AND THEIR ACCESSORIES
- SC 46C - LF CABLES AND WIRES
- SC 46D - CONNECTORS FOR RF CABLES
- SC 46E - FIBRE OPTICS

TC 48 - ELECTROMECHANICAL COMPONENTS FOR ELECTRONIC EQUIPMENT

- SC 48B - CONNECTORS
- SC 48C - SWITCHES
- SC 48D - RACKS AND PANELS

TC 51 - MAGNETIC COMPONENTS AND FERRITE MATERIALS

TC 52 - PRINTED CIRCUITS

TC 55 - WINDING WIRES

FIG. 6 PASSIVE COMPONENTS

TC 12 - RADIOCOMMUNICATIONS

- SC 12A - RECEIVING EQUIPMENT
- SC 12B - SAFETY
- SC 12C - TRANSMITTING EQUIPMENT
- SC 12D - AERIALS (ANTENNAS)
- SC 12E - MICROWAVE SYSTEMS
- SC 12F - EQUIPMENT USED IN THE MOBILE SERVICES
- SC 12G - CABLED DISTRIBUTION SYSTEMS

TC 29 - ELECTRO-ACOUSTICS

- SC 29B - AUDIO ENGINEERING
- SC 29C - MEASURING DEVICES
- SC 29D - ULTRASONICS

TC 60 - RECORDING

- SC 60A - SOUND RECORDING
- SC 60B - VIDEO RECORDING
- SC 60C - APPLICATION OF EDUCATIONAL OR TRAINING EQUIPMENT AND SYSTEMS

TC 80 - ADVANCED ELECTRONIC NAVIGATIONAL SYSTEMS

ACET - ADVISORY COMMITTEE ON ELECTRONICS AND TELECOMMUNICATIONS

FIG. 7 EQUIPMENT AND APPLICATIONS

Sections of the I.E.V. of particular interest to the communications industry include Publication 50 - General Index, Chapter 5 - Fundamental Definitions (now in revision) - Chapter 55 - Telegraph and Telephony, Chapter 60 - Radiocommunications, Chapter 62 - Wave guides, Chapter 531 - Electronic tubes and Chapter 902 - Radio Interference.

The next group of committees activities are listed in Figure 5: Active Components, and Figure 6: Passive Components. Technical Committee 40 prepared one of the first 'electronics' recommendations to be issued by the IEC, Publication 62 (1952) Colour code for fixed resistors. Also in 1952 was issued Publication 63 - Series of preferred values and their associated tolerances for resistors and capacitors. The latest revisions of these Publications date from 1974 and 1963, respectively.

Figure 7 tabulates the committees dealing with equipment applications.

TC12: Radiocommunications, may truly be called the father of the electronic committees. Originally set up as Advisory Committee No. 12 in 1927, its first tasks were the standardization of the dimensions of electronic tubes, particularly the bases, and the drafting of safety rules for broadcast receivers. That original object might well seem modest now, yet it led to AC12's first recommendation in 1938, IEC Publication 58: Recommendations for dimensions, definitions and rules applicable to radio engineering.

This work was resumed in 1947 and resulted in the issue of the first editions of two basic IEC Recommendations in the electronics and telecommunications fields - Publication 65 on safety requirements, published in 1952, and Publication 67 on dimensional standardization on electronic tubes, published in 1954.

The extremely rapid growth of electronics that has occurred since 1945 was matched by an expanding volume of international trade. The free flow of goods was hindered, however, by the existance of differences between national regulations or standards and even the possibility of making a fair comparison of technical performance by agreed methods of measurement.

It was, therefore, decided in 1950 to set up within TC12 four sub-committees entrusted with work relating to equipment, such as safety rules and measuring methods, and components. Each of these fields soon proved too wide for one sub-committee and in 1954 a new phase was embarked upon and TC12 began to assume its present form, dealing with equipment only. The committees listed in Figure 5 and 6 were progressively set up to deal with components standardization.

This division of responsibilities required an organization to co-ordinate the various activities. Since 1955, this had been done by the Advisory Committee on Electronics and Telecommunications (ACET). The organization of this body has been influenced by the need to divide equipment into two main categories, domestic and professional equipment. Professional equipment covers a very wide field and it is essential to work in close co-operation with organizations concerned with the basic characteristics of telecommunications equipment, the International Telecommunications Union (ITU), the International Radio Consultative Committee (CCIR) and the International Telephone and Telegraph Consultative Committee (CCITT). The last two organizations mentioned derive their initials from the French title of the committees.

TC12 is presently divided into seven sub-committees although a favourable decision was reached at TC12's last meeting in Tokyo in October of 1980 to form the eighth sub-committee.

SC12A - Receiving Equipment

SC12A deals primarily with measuring methods and does not at the present time specify performance requirements.

Publication 315: Methods of measurement on radio receivers for various classes of emission, is intended to cover all types of receivers both domestic and professional. Six parts have been published and a seventh, on FM receivers, is in the final approval stages.

Publication 107: Recommended methods of measurement on television receivers (2nd edition) was issued in 1977. A second part dealing with the audio section is in the printing stage.

The problems of spurious radiation from receivers led to the study of suitable measurement methods and Publication 106: Work on interference measurements has been closely co-ordinated with CISPR, who recommend limits, and the work of SC12A on methods of measurement has been progressively transferred to CISPR.

SC12B - Safety

SC12B has been entrusted with the drafting of safety rules for domestic electronic appliances and its main task is the continuous updating of Publication 65: "Safety requirements for mains operated electronic and related equipment for domestic and similar general use". The scope of the work, therefore, also covers equipment dealt with by other Technical Committees.

Safety requirements of electronic flash equipment for photographic purposes have also been covered in Publication 491.

SC12C - Transmitting Equipment

SC12C deals with standardization work on radio transmitting equipment of all types. This is a typical example of where an effort has been made to ensure that the work is complimentary with that of the CCIR.

Recommendations include: Publication 244: Methods of Measurement for radio transmitters, for which presently seven parts have been issued. Publication 215: Safety requirements for radio transmitting equipment. Here the special hazards inherent with this type of equipment required an international code of good practice to be formulated. For similar reasons SC12C prepared Publication 657: Non-ionizing radiation hazards in the frequency band 30MHz to 300,000 MHz.

SC12D - Aerials (antennas)

This committee deals with all kinds of antennas and its publications to date include Publication 597: Aerials for the reception of sound and television broadcasting in the frequency range 30MHz to 1GHz.

SC12E - Microwave Systems

This committee, set up in 1969, has from the outset, closely collaborated with CCIR. Standards include Publication 487: Methods of Measurement for equipment used in terrestrial radio-relay systems and Publication 510: Methods of measurement for radio-equipment used in satellite earth stations.

SC12F - Equipment used in the Mobile Services

This committee is actively working on several parts of Publication 489: Methods of measurement for radio equipment used in mobile service. Nine parts have been issued so far.

SC12G - Cabled Distribution Systems

SC12G held its first meeting in 1975 and has the responsibility of producing both recommended performance requirements for cable systems and measurement methods. There are currently seven documents at the Six Months' Rule stage and a publication is expected in approximately one year.

TC29 - Electro-Acoustics

TC29 has three sub-committees, SC29B - Audio Engineering, SC29C - Measuring devices and SC29D - Ultrasonics. The first publication 89 on audio apparatus issued in 1957 has been replaced by Publication 268: Sound system equipment. This latter standard has been continually updated and presently comprises 15 parts, several parts being augmented by supplements.

Among other important work, the committee has prepared standards for testing hearing aids contained in Publications 118 and 224.

There are also 23 other publications put out by these sub-committees including Publication 581: High fidelity audio equipment and systems including minimum performance requirements and parts dealing with record players, magnetic recordings and amplifiers.

TC60 - Recording

TC60 deals with all aspects of recording and has three sub-committees: 60A - Sound recording, 60B - Video recording, and 60C - Application of educational or training equipment and systems.

More than 20 publications have been issued of which the most notable are Publication 94: Magnetic tape sound recording and reproduction systems, Publication 98: Processed disk records and reproducing equipment, Publication 347: Transverse track recording (video), Publication 511: Helical-scan video-tape cassette system using 0.5 in (12.7 mm) magnetic tape.

Reliability and Safety (See Figure 8)

IEC Publication 68: Basic environmental testing procedures is one of the best known international standards and presently comprises 42 booklets totalling more than 1,000 pages. The first edition of this publication appeared in 1954 and was prepared by TC50.

TC61: Safety of household and similar electrical appliances, prepares safety requirements for electrical appliances, mainly for household purposes or similar applications, where there is no other IEC committee dealing with the products safety. The recommendations of TC61 are given in Publication 335, a series of 35 booklets dealing with specific subjects that are being regularly updated and expanded.

The various activities on safety are co-ordinated through the Advisory Committee on Safety (ACOS).

Interference and Compatibility

A new committee, TC77, was recently established to prepare standards concerning electromagnetic compatability of electrical and/or electronic equipment, between themselves and with electric power networks. The programme of work is to be co-ordinated with other Technical Committees and particularly with the CISPR (International Special Committee on Radio Interference) whose activities are indicated in Figure 9.

CISPR is a Special Committee under the sponsorship of the IEC. Its duties are to lay down measurement standards and draw up proposed limits for the tolerable radio interference produced by electrical equipment. It deals with the protection of radio-communications which is considered one of the factors affecting international

TC 50 - ENVIRONMENTAL TESTING

SC 50A - SHOCK AND VIBRATION TESTS
SC 50B - CLIMATIC TESTS
SC 50C - MISCELLANEOUS ENVIRONMENTAL TESTS
SC 50D - FIRE HAZARD TESTING

TC 56 - RELIABILITY AND MAINTAINABILITY

TC 61 - SAFETY OF HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES

NOTE: - SC 12B DEALS WITH SAFETY OF ELECTRONIC EQUIPMENT

- SC 66E DEALS WITH SAFETY OF ELECTRONIC MEASURING EQUIPMENT

TC 74 - SAFETY OF DATA PROCESSING EQUIPMENT AND OFFICE MACHINES

TC 75 - CLASSIFICATION ON ENVIRONMENTAL CONDITIONS

ACOS - ADVISORY COMMITTEE ON SAFETY

FIG. 8 RELIABILITY AND SAFETY

TC 77 - ELECTROMAGNETIC COMPATIBILITY BETWEEN ELECTRICAL EQUIPMENT INCLUDING NETWORKS

CISPR - INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

SC A - RADIO INTERFERENCE MEASUREMENTS AND STATISTICAL METHODS

SC B - INTERFERENCE FROM INDUSTRIAL, SCIENTIFIC AND MEDICAL RADIO FREQUENCY APPARATUS

SC C - INTERFERENCE FROM OVERHEAD POWER LINES, HIGH-VOLTAGE EQUIPMENT AND ELECTRIC TRACTION SYSTEMS

SC D - INTERFERENCE RELATED TO MOTOR VEHICLES AND INTERNAL COMBUSTION ENGINES

SC E - INTERFERENCE CHARACTERISTICS OF RADIO RECEIVERS

SC F - INTERFERENCE FROM MOTORS, HOUSEHOLD APPLIANCES, LIGHTING APPARATUS AND THE LIKE

FIG. 9 INTERFERENCE AND COMPATIBILITY

trade in industrial products. Strong efforts are made to reconcile the interests of radiocommunications users and electrical equipment manufacturers, through a balanced representation of both parties.

There is presently sixteen CISPR publications covering measuring equipment, test methods and recommended limits for various classes of equipment. Interference can also occur between radio equipment and a very important publication CISPR 13: Limits and methods of measurement of radio interference characteristics of sound and television receivers is available on the subject.

5. THE FUTURE

It is just as impractical to attempt to outline all of the future work of the IEC as it would have to be to tell all of the work that is presently in progress.

It is interesting to note, however, three specific fields of interest in the communications area.

Two-way cabled distribution systems: A new working group of SC12G has just been established to determine limits and methods of measurement for cabled distribution system for reverse feeds.

Cable distribution systems using optical fiber cables: This is also a new working group that has just been established in SC12G. As well, TC46E is working on standards for the fiber optic cables.

As mentioned earlier TC12 has recently approved the formation of a new sub-committee to deal with the transmission and reception of written message information. We have all added new words such as Antiope, Prestel, Teledon, Ceefax, Oracle, Captain, Videography, Videotext, Teletext and Teltex. A great deal of work will be required in order that some standards will allow what some people are calling an information revolution to develop to its available potential. There are major conflicts on the transmission system itself. The code transmission method which has been the normal way of transmitting written messages should be examined in light of the fact that the display terminal is a video display terminal or television set and not a printer. Perhaps, as a standard, we may see a pattern transmission method emerge which could use the potential of the display device.

In conclusion, the publications of the IEC are the result of many thousands of man hours by dedicated people. In the past the problems have been difficult to resolve and it appears that the future holds no major solutions.

At the 45th General Meeting of the IEC held in Stockholm, Sweden, in June of 1980, 900 delegates representing 38 National Committees were in attendance. At this meeting over 100 draft standards were agreed to be circulated. It is hardly possible to adequately describe the importance and results from this immense volume of continuing work in a survey such as this talk. However, detailed information can be obtained from three IEC publications that appear annually.

The IEC Handbook lists the officers on the Commission, provides the addresses of the National Committees and the names and addresses of the Presidents and Secretaries in your country, and gives basic information about all IEC Committees.

The Report of Activities, for the preceding year, gives an outline of the technical work that has been finalized and the subjects under consideration in the various committees. Also it has a useful subject index and lists the publications of each Committee.

Finally, there is a Catalogue of Publications. This lists the publications numerically and gives a brief outline of contents. An alphabetical subject index is also given.

All the publications mentioned can be obtained from:

Central Office of the IEC
(Sales Department)
1 rue de Varembé
Ch-1211 Geneva 20
Switzerland.

New Issues in Standards Development

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Abstract

During the 1970's, opportunities offered by advances in data processing and telecommunications led to new efforts in standardization, which produced some solutions implemented by the end of the decade. But compatibility between different standards, and their efficiency, leads to a second order of investigation for which systems architecture modelling offers promise. A third category of activity is indicated for new areas such as electronic office equipment and services, domestic information retrieval, and new cable and satellite technologies for service delivery. As well as a year of significant developments in ISO and IEC, 1980 closed one study cycle in CCITT and opened another. New issues of interest to PTC 81 are noted.

1. WHAT STANDARDS ARE, AND ARE NOT

Salt has been defined as "what makes potatoes taste bad when you don't put it in the water when you boil them". At Concordia University in Canada, a seminar entitled "Putting Standards to Work" sponsored by the Standards Council of Canada concluded that: "Standards are written as communciation media to avoid re-inventing the wheel". Standards might be redefined as "an ingredient which makes regulations and specifications unpalatable when they are not put into the production, supply, marketing and regulatory process".

2. PARTICIPATION IN STANDARDS FOR TELECOMMUNICATIONS

The development, marketing and use of telecommunications goods and services involves an ever widening community of interests. Unless in the writing and approval of standards there has been representative national participation, and effective national procedures, telecommunications components, equipment, services and national regulations lack credibility and hence utility. International telecommunications regulations and standards vary in their impact on national situations. Representative participation is even less clear in the international standardization and regulatory process.

3. STANDARDS ISSUES FOR THE NEAR FUTURE

Companies manufacturing an existing range of computer systems as well as those producing office machines are interested in the opportunities for office automation systems combining word processing, correspondence management, management information, management support functions and integration of inter-office communications. Long Distance "officemation" will follow the present market for small systems which automate a single area of office activity.

Operating organizations, whether government or government-regulated, are introducing new telecommunciations network technologies, some of which are entering competitive market areas.

Some key areas of national and corporate interest, which are reflected in International papers and debates are:

1. Relationship of regulations to the orderly development of national telecommunications services to meet national needs.
2. Relationship of telecommunications regulations, standards and certification to domestic employment and import - export trade balances.
3. Development of standards certification procedures and technology.
4. Priorities for standards needed for the future, and time frame for results.
5. Financial and human resource management for participation in the development of such standards.
6. Interactions between national and international factors in national and international standards writing, approvals and application.
7. Government purchasing and industry support programs.

4. THE REGULATORY ENVIRONMENT

The development of international Telegraph Regulations (and later, Telephone Regulations) (1) was commenced by government administrators and "electricians" over a hundred years ago. The alignment and adequacy of ITU Regulations with contemporary procedures, efficiency and administration under changing international situations is reviewed every ten years or so by an Administrative Telephone and Telegraph Conference of the International Telecommunications Union (ITU). For example, questions are arising in many organizations which sooner or later will lead to requests for the International Telecommunication Union to examine whether there is a need for Data Transmission Regulations, and if so what is the set which can be agreed between nations signatory to the ITU Convention.

Administrative Radio and Satellite Conferences are required more frequently to update the ITU Radio Regulations (2), which are more directly enforceable under national laws. Technical solutions were arrived at in response to problems which might have produced conflict between countries. Compromises in potentially explosive issues were achieved through diplomacy and emerged through the development of technical procedures. One of these was removal of unused HF frequency assignmetne from the ITU Register, thus freeing a potentially large number of frequencies for re-assignment to developing countries requesting help to identify HF frequencies. (3)

The International Telecommunication Union began as an International Treaty between nations which admitted public telegraphic services between their populations. Operational procedures were entirely manual. It was necessary to agree the sharing of the international component of the charge recovered from a client when the service crossed an international border. The latter required rules for the counting of words and addresses. Operations required fixed procedures for translation at border stations where there was a language change, or secret telegrams passed, or government priority to be observed. As the electric telegram service supplemented some of the postal service, which was already the subject of bi-lateral and international agreements, and the telegram service operated in most cases under postal authority, the Universal Postal Union was a consideration, and is becoming so again. Who should regulate electronic mail?

Underlying and supplementing ITU mandatory regulations and all the national regulatory environments for telecommunications are the Telegraph and Telephone Recommendations of the CCITT, some up to fifty years old. National operating procedures, tariff principles, and technology standards and practices govern what a national telecommunications user gets and what he pays for when he obtains an international connection.

5. SCOPE AND TERMS OF REFERENCE OF THE CCITT

The mandate of CCITT is given under Article 11 of the ITU Convention (4) as follows:

71 "The duties of the International Telegraph and Telephone Consultative Committee (CCITT) shall be to study technical, operating and tariff questions relating to telegraphy and telephony and to issue recommendations on them.

72 In the performance of its studies, each Consultative Committee shall pay due attention to the study of questions and to the formulation of recommendations directly connected with the establishment, development and improvement of telecommunication in developing countries in both the regional and international fields."

Membership of the CCITT is given under the same Article 11 as follows:

73 The International Committees shall have as members:

a) of right, the administrations of all Members of the Union;

74 b) any recognized private operating agency which, with the approval of the Member which has recognized it, expresses a desire to participate in the work of these Committees.

Under Article 68, participation is extended to:

377(1) International organizations and regional telecommunication organizations mentioned in Article 32 which coordinate their work with the International Telecommunication Union and which have related activities, may be admitted to participate in the work of the Consultative Committees in an advisory capacity (e.g. IEC, ISO and WHO).

(2) Scientific or industrial organizaitons, which are engaged in the study of telecommunciation problems or in the design or manufacture of equipment intended for telecommunication services, may be admitted to participate in an advisory capacity in meetings of the study groups of the Consultative Committees, provided that their participation has received approval of the administrations of the countries concerned.

CCITT under the above mandate procedes according to the working arrangements of the two ITU International Consultative Committees as defined in the ITU General Regulations, including:

a) the CCITT Plenary Assembly, held every 3 or 4 years.

b) Study Groups set up by it, and questions which it assignes to them.

c) a Director, elected by a Plenary Assembly and appointed in accordance with the ITU General Regulations, and who is empowered to enter into direct contact with the Chairmen of the Study Groups.

d) A World Plan Committee, and such Regional Plan Committees as jointly approved by the Plenary Assemblies of the International Consultative Committees.

e) Some additional rules of procedure given in the CCITT Book (5).

A need for national telecommunications regulation is recognized by countries at all stages of development and industrialization. A minimum set of government-to-government agreements has long been required to permit and facilitate international connections. A uniform set of underlying national operating procedures, tariff principles, equipment functions and service access arrangements is required. Therefore the CCITT is supported by over one hundred and fifty countries.

6. ADOPTION OF STANDARDS

National adoption of a CCITT Recommendation is given effect when utilized by a national operating agency, in operations, tariff principles or technology. In a regulated monopoly service such as telephony (6) or telex, this is direct, but subject to some national regulatory process, agency or commission.

In Canada, public data network service is available from competing organizations (7). Under responsibility of the Standards Council of Canada (SCC), National Standards are developed for data communications interfaces, based upon CCITT Recommendations and ISO Standards. This is done in a designated Standards Writing Organization - the Canadian Standards Association (CSA). Its procedures conform to ISO rules. SCC is the national body representing Canada in ISO and in IEC and is active in the Pacific Area Standards Congress, a forum for the exchange of information about standards, including those of interest to PTC 81 participants.

Preparation of Canadian contributions to IEC, and to computers, office machines and data communications matters in ISO, is delegated to technical committees of CSA. So is the mandate for national standards. They adopt IEC, ISO and some CCITT standards for Canadian use. There are now 40 CSA standards in computers and Data Processing (8). The newest CSA technical committee deals with Videotex.

In turn, CSA standards for computers, information processing and office machines are reviewed and can be adopted by a standards activity supported by the Advisory Bureau for Computing. This is arm of the Federal Department of Supply and Services. Treasury Board (9) Management Directives refer to their use in purchasing specifications. Consultative participation by industry is provided for in the Federal supply process.

7. VLSI AND SOFTWARE ENGINEERING

Industrialized countries see standardization for the interconnection of data processing installations not only as urgent for enhanced computer/communications applications in government and private sectors, but also a significant factor in national industrial strategy for the production of Very Large Scale Integration devices ("chips").

Some Canadian projects, for example COSTPRO (a trade documentation project), EDP FUNDS TRANSFER, ELECTRONIC MAIL and TELIDON, would obviously benefit from a Canadian Open Systems model compatible with developments in ISO and CCITT but available to national system designers and users as a CSA standard. On this model, compatible protocols for specific applications could then be developed. The link to Canadian microelectronics industry has yet to be more broadly examined.

The Province of Ontario, where 41,000 people are estimated to be employed by micro electronics firms, has already set up a task force to examine the impact of this multi-million dollar industry on the provincial economy. Shortcomings to be investigated include chronic labor shortages, lack of research and development support, and the need for developing domestic and export markets (10). This kind of task force is to be found in many countries.

Interfaces need to be developed that are easy to use and integrate many different capabilities. Models and techniques need to be developed to represent and analyze information processing and data flows (11). Canada and other countries have started public data networks, but the comptuer industry has not yet achieved the level of software standardization needed to exploit the economic and social possibilities which lie in Open Systems Interconnection. Many of the interface protocols can be realized in "chips".

The European market for microprocessors used in a broad range of industrial and consumer equipment is estimated to grow 40% next year. One large European manufacturer will reach $300 million worth this year, about half from sales to outside customers. Heavy investments are required in exotic production equipment such as ion implanters and the new colimated electron beam technology.

8. PRIORITIES AND TIME FRAMES

Need for a telecommunications standard originates in the mind at any stage of the design and production of a new or revised telecommunications component, system, network or service. Standards continue to be of concern in marketing, product support, cost recovery and the regulatory environment.

An abreviated history of interfaces to access public networks will illustrate some priorities and timing factors in arriving at, and in using such a standard. Elements of CCITT Recommendation X.21 "Interface between Data Terminal Equipment (DTE) and Data Circuit Terminating Equipment for Synchronous Operation on Public Data Networks" were first published in 1972, based upon a 1968 question to meet the needs of designers and users up to 1976. Enhancements, including multiplex connection to a single line, were approved at the Plenary Assembly of CCITT in 1980.

A new question set in 1972 on the packet mode of operation led to a first review of contributions at Geneva in 1974. Designers of interfaces to public data networks planning to operate in the packet mode were extremely active up to the very end of the CCITT study period which closed in 1976. Though some designers favored circuit technology, and still do, they did not negate the work which was approved at the 1976 Plenary as CCITT X.25: "Interface between data terminal equipment (DTE) and data circuit terminating equipment (DCE) for terminals operating in the packet mode on public data networks."

Subsequently, when a Canadian packet network service (DATAPAC) commenced commercial operation in June 1977 and the French TRANSPAC in December 1978, terminals manufacturers could begin to design compatible packet mode terminals and software for markets in at least two countries. To accommodate all the thousands of non-packet terminals, other CCITT Recommendations for network access were also developed. This is the standards principle of avoiding retro-fit.

In doing so, however, as new implementations occurred in more countries differences were discovered and reported in detail.(12) The standardization process did not stop at this point. The frame level Link Access Procedure (LAP) procedure defined in X.25 (1976) was not entirely conpatible with the High-Level Data Link Control (HDLC) procedures then being standardized by ISO (13). Alignment was reached in 1977 by addition of the balanced LAP procedure (i.e... LAPB) at an ad-hoc meeting of ISO and CCITT experts at Geneva. The DDX network in Japan and RETD in Spain started with LAP(B), and so did Euronet. During the period from 1977 to 1980, work continued. Technical agreements were reached on a number of important points, as summarized in Table 1 (14). This is the standards policy of graceful enhancement.

Table 1
Some Technical Agreements reached in CCITT with ISO consultation leading to a revised X.25 (1980)

Year	Item
1977	End-to-end diagnostic fields
1978	National Facility market Formatting extension policy New call progress signals
1979	INCOMING CALL Timeout Diagnostic codes DIAGNOSTIC packet Delivery Confirmation (D) bit Packet and Window Size Negotiation Detailed error handing Throughput Class Negotiation Logical Channel Assignment Rules

Table 1 includes only those points leading to a common X.25 interface. It does not cover optional facilities available on some networks.(15) The essential features of the 1980 versions of X.21 and X.25 will be supported on several networks not mentioned above, according to communications from their designers.

9. MANAGEMENT OF THE PROCESS

With all these and other expanding demands on the standards areas concerned, there is increasing interest by management at all levels in planning for effective use of resources: corporate, government ministry, national, and international. Evaluation of priorities and timing of results grows more important as demands on travel budgets and experienced manpower with hands-on-know-how continue to increase.

Successful corporate design and marketing strategies, national industrial programs, and even government social and political objectives require shrewd assessment, careful control, and intervention at policy level on the part of management unwilling to accept second place in standards or the penalties of falling behind in technology and commerce.

Due to new service and technology developments of common interest, concerned ISO Technical Committee and CCITT Study Group Chairmen met last September at Geneva. An abstract of the meeting notes is annexed.

10. ASSESSMENT OF RESULTS

- To quote Mr. Clayton Andrews, a former IBM Director of Standards, EDP Products, "The challenge is to consolidate gains without frustrating future developments. The term 'anticipatory standards' is often used. Vested interests will play an active role. We can expect acceleration of standards activities. In no other field is so much interest vested in the future."

- D.H. Wardrop, Director of Corporate Development, Manitoba Telephone System, has said: "The market is ripe, and the technology capable of serving that market is on the threshold of enormous change from the convergence of computers and telecommunciations."

- At the CCITT Colloquium on Teleinformatics in Montreal in June this year, Mr. Norm Byrne, Executive Vice-President, Teleglobe, Mr. Donald Cruickshank, President, CTCA, and Mr. Dennis Hall, President, BNR, agreed that it was not technical problems that were slowing the introduction and integration of new non-voice services, but rather the achievement and implementation of compatible standards.

- In closing let us note that the history of telecommunications is full of examples of catalytic action. Standards activity has performed a distinguished service -- it has operated in a field where the stakes, often hidden, are often very large; where opportunities as well as pitfalls are not always obvious. Leadership, insight and vision must be exercised with wit, subtlety and precision if expectations are not to be disappointed in the exciting prospects ahead.

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Annex
ISO/CCITT Meeting, Geneva,
22 September 1980

It was mentioned that existing arrangements for voluntary cooperation had yielded useful results. However, ISO felt that better arrangements may be useful for the future, due to the rapid movement of technology. More frequent contacts at planning and working levels may be required.

It was proposed from ISO that joint CCITT/ISO planning and review would enable better coordination in the complementary work of the two organizations. This might take the form of periodic meetings of a CCITT/ISO standing committee where questions of mutual interest could be discussed.

In view of difficulties in a joint standing committee it was suggested that meetings be convened by ISO to which representatives of CCITT would be invited. This would have advantages similar to a joint standing body. CCITT welcomed the prospect of such invitation, and thought that representatives selected by the Directof of CCITT on the basis of issues identified, and attending as observers, would take part in technical and planning discussions on areas of common interest.

A FRIENDLY USER ENVIRONMENT

by Alan K. Okinaka, Hawaiian Telephone Co.

Abstract

A friendly user environment must be created where the user and the machine can support each other, such that the effectiveness of the user and the efficiency of the machine will work together to create and preserve the most conducive and productive environment possible.

But a friendly user environment does not define an environment that is "easy" for the user. At the peak of frustration, the user may believe the easy environment to be the most desirable, however, the environment that will be most productive (getting the most done with as little as possible) will draw on the resources of both the user and the machine.

1. INTRODUCTION

This paper addresses the very basic problem of properly intefacing the user with any system (terminals, networks, and computers). Although different situations and applications determine the actual characteristics of the user-machine interface, it is important that the easily controlled and configured machine is not designed to dominate the interaction process.

2. GENERAL SYSTEMS

Have you often wondered why certain automobiles give you a backache on a long drive and others don't? Why do our modern microwave ovens have such complicated controls? What is medium heat on an electric range? How do you initially react to any new equipment? Remember when control knobs on cars were nice and shiny but didn't tell you what they did? Do you love your instamatic camera because you hate adjusting shutter speeds and openings? Ever wonder why a typewriter keyboard is laid out the way it is? Does your CRT terminal require a shade to permit ease of reading?

These are some of the environments that are created for us, by us, and we live in them consciously and unconsciously. Notice that these are just small problems which do not include the even bigger concerns of pollution and foreign policies of our government.

Our needs demand a society that is heavily impregnated with the benefits of advanced technology. Technological spin-offs are popular processes that take any high level technology and utilize selected concepts to provide products and services that are considered beneficial to society. Our demand on new products and services has reached a point where advancements are unconsciously expected and, therefore, assumed to be a normal part of our lives. There is a danger in this perspective of technology in that the effects and impacts that new products make on society are often neglected. There is some awareness of these impacts, however, a major part of the population is unaware, ignores, or does not believe that there is a problem. We assume that these products are natural evolutions of nature, and then automatically believe that it is alright--that it aligns with the "master plan" of life itself. We often hear ourselves saying, "I guess this is the way it is, huh?" There are some problems that we recognize but--"someone must be looking into it," we often say, or we feel that if we ignore the problem long enough it will solve itself.

2.1 USER ATTITUDE

The word "apathy" is often used to describe this phenomenon, but a "remote attitude" better illustrates what is happening. This feeling of remoteness evolves from our low level of interaction with products, services, and systems, that we use everyday.

A very simple example of the remote attitude is how we treat the energy crisis. I believe that everyone is somewhat aware that there is a limited supply of fossil fuel. This awareness, however, does not translate to a fuel user's problem. It is seen more as a fuel supplier's problem. Crime and pollution occupies our minds whenever we watch television news or peruse the daily newspaper, but again--these do not translate directly into our immediate neighborhood. There is an awareness that we could be a assaulted and robbed and that we probably contribute to the problem of pollution, but we unconsciously convince ourselves that these are the police department's and government's problems. The pollution in Los Angeles is viewed as a problem there, and Hawaii has nothing to do with it. On the contrary, as long as we purchase products and services from Los Angeles, we in Hawaii are involved in their problems.

In both examples, the system, a product, or service has been looked upon as being another world that is put there to serve our world. If a problem exists there, we feel it does not affect our world, and assume it will solve itself eventually. Whether it is a human being or a machine in this other world, we treat them the same. If you do not believe this, try and recall what your mailman looks like. How about the guys that pick up your garbage twice a week? These people have become part of the "invisible" society belonging to that other world when they perform their jobs. Whether these are services provided by machines or by humans, we recognize only the service.

3. TELECOMMUNICATION SYSTEMS

A question should be asked at this point--what does all of this have to do with telecommunications or computer communications? The answer is simple . . . quite a bit. Our attitude towards existing telecommunication products and services has affected the quality of user interaction with systems and machines. The user is often neglected because the machine is easier to define and control, but the worst is that the user eventually accepts this neglect and adapts to it. Often, this process or procedure, deficient of human considerations, becomes the norm and is accepted as a standard, never to be challenged. The easily-controlled machine is constantly improved, but consideration for human engineering is secondary to the design of the system's features.

Besides everything we interact with daily, consider one of the services in our telecommunications field. Did you realize that when Martha ran your switchboard long ago, that she provided all the services that our modern electronic switches will begin to provide? They were a lot slower, but definitely provided. Back in those simple country party-line days, Martha knew that the person you were calling was not at home but visiting relatives, and therefore, she forwarded your call to that number. If the party was busy on another call, Martha would call you later when the connection was free. We now call this feature camp-on. When advanced technology moved in, Martha was moved out along with all those nice features. Today these features are returning as a technological innovation; it is more a return of some nice old services. Countless products and services have been provided to enhance communications, but their introduction is difficult to believe as the user becomes more isolated from the service. Enhancement is often associated with enrichment, but this relationship is questionable when we realize how resources are wasted in our society. This in itself is another topic.

A friendly user environment must be created where the user and the machine can support each other, such that the effectiveness of the user and the efficiency of the machine will work together to create and preserve the most conducive and productive environment possible.

But a friendly user environment does not define an environment that is easy for the user. At the peak of frustration, the user may believe the easy environment to be the most desirable; however, the environment that will be most productive (getting the most done with as little as possible) will draw on the resources of both the user and the machine.

If we examine the components that make up the friendly user environment, it is obvious that this interface is not limited to only the physical relationship, but more importantly considers the psychological interaction.

The discussion hereafter will be confined to the area of telecommunications and computer communications. However, with a slight change of the subject words, the description is applicable to any interaction between user and the machine which is, as we have considered before, "the other world."

3.1 INTERACTION COMPONENTS

There are four major areas that cause the user-machine interaction problem to be very visible. Each component does not stand alone, but is closely related to the characteristics of the other components.

1. System Response - Notice how your level of patience is inversely proportional to the length of time a system takes to respond to your inquiry. Mooers' Law describes this in a capsule--the system will tend not to be used if getting the information is more painful than not having it. Excessive delays lead to irritation, which initiates and feeds on the user's disorientation of the problem and the problem-solving process.

2. System Pressures--Many machines and systems are designed to be process-efficient and, therefore, impose their speed, functions, and language on the user. The user is expected to adapt to the machine. Users in general are given the impression that the machine requires precise commands or an electronic tantrum will ensue.

3. System Hardware--Machines blink, beep, click, tilt, hum, and electronically hibernate. Some of these "attributes" are designed to help the user to instill a sense of confidence that the system is operating. In general, these aids are very primitive and don't blend in with the user's environment because consideration for the user is not included.

4. System Errors--Error messages that the system generates are usually difficult to understand. There may be a precise meaning hidden in the computer jargon, but a user cannot be expected to decipher error messages while he is interacting with the system. An error must be clearly described, besides being pointed out. The phrase is

often heard, "This system was written by programmers for programmers." Systems must be written for users, who are the people with the actual requirements.

These four components suggest that the user is a victim of the other world, which promoted and implemented all these inadequate services. In reality, the environment exists because we allow this to happen. A friendly user environment must be more than a machine with a nice color scheme and a lot of blinking lights; and if the total function of systems is designed without the user in mind, this friendly environment will not be created. The irony of this other world is that the user is a part of it because the user also provides a product or service. In other words, if users demand a friendly user environment for products and services they provide themselves, then the remote attitude that creates this other world would disappear. This may seem very philosophical and ideal--but however, it is also very simple. It requires that each process or procedure initiated must take consideration for the user as top priority. There is no doubt that the machine is efficient; but until the interface permits the user's requirements to be effectively satisfied, any product or service will not be properly utilized and, therefore, productivity will not be optimized.

A single button that goes on with a push and off with another push is a very friendly environment. The user provides the decision and finger pressure, and the button provides the translation to an on or off condition. If the service is more complex, such as users operating a computer, then several layers of subsystems are involved to truly engage the user-machine interaction for a friendly user environment.

Throughout any user-machine session, there is a myriad of items to consider for a friendly user environment. On the physical level, consideration must be given to such simple concerns as the location of the power switch, indicators and strapping switches, color scheme, physical weight, printing, fan noise, those annoying beeps to tell you the line is near its end, the eternal clicks for the positive feedback that a character was indeed entered, the layout of the keyboard, the changing of the inked ribbons, the loading and alignment of the paper, the physical appearance, and the readability of printing or a CRT display. Certain terminal manufacturers incorporate some very user-oriented schemes, but often only a few nice features are built in and others neglected in every system. These physical items are quite obvious and any user can easily list them by stepping through the procedure of turning on a terminal system and connecting it to a computer. Simple questions will suddenly be asked by the user . . . "Why do they locate the power switch in the back where I must blindly reach for it?", or "How can I turn off that beep?"

3.2 NETWORK INTERACTION

Another level is encountered when a user must access the computer via a data network. These networks are supposedly designed to be transparent, or invisible to the user and computer. However, frequent mysterious failures, burdensome connection and disconnection procedures, and nonsense network messages thatd don't correlate with other known network characteristics make the network very visible. If a user tolerates these network deficiences, he has immediately created the other world and the poor user environment will continue to exist. Finally, the user reaches the level of interacting with the computer. The user is introduced to the inadequacies of system prompts, error messages, system response times, and interruption requests. The misunderstanding of the system structure does not permit the user to make full utilization of the system for his benefit.

4. CONCLUSIONS

This paper does not attempt to list recommendations to create any friendly user environment. Each environment differs and the users differ. The point I'm making is that we need to emphasize the importance of considering the user. The user must be considered totally in all features and functions that are designed into any system. Today, machines are more efficient than they need to be. Faster processing does not satisfy the requirement for better user interaction. In order that the user and machine support and enhance each other, a friendly user environment must exist.

Traffic Behaviour of Telephone Subscriber

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Abstract

In this work a preliminary attempt was made to study, in depth, the traffic behaviour of Israeli private telephone subscriber through the introduction of socio-economic aspects. This was accomplished by combining two different surveys, namely, socio-economic survey and traffic survey.
The results of the preliminary tests may indicate the differences in the traffic behaviour of telephone subscriber belonging to various socio-economic classes, emphasizing the existing strange pecularities and proposing possible ways for their correction.

1. INTRODUCTION

During the past several years great efforts were exerted, in various countries, in the study and analysis of traffic behaviour of telephone subscribers[1,2]. These studies may lead to some system planning improvement, greater service efficiency and its adjustment to subscriber requirements.

Special devices - called line scanners, were developed for the measurement of traffic characteristics of telephone subscribers.

Telephone subscribers were generally divided into 4 groups: PBX, commercial subscribers, private subscribers, and special subscribers. Each group was analized separately.

In this work a preliminary attempt was made to study in depth, the traffic behaviour of Israeli private telephone subscribers through the introduction of socio-economic aspects.

A preliminary test was performed on a limited sample of - private subscribers connected to one exchange by combining two different surveys, socio-economic survey and a traffic survey.

The pretest results are of a very limited nature and do not claim to indicate an applicable global methodology and generalize quantitave results.

Nevertheless, it appears to us that these results may be of some use to telephone administrations by reflecting the differences in the traffic behaviour or private telephone subscribers belonging to various socio-economic classes emphasizing the existing strange pecularities and proposing possible ways for their corrections.

2. DATA COLLECTION

The gathering of socio-economic data was performed through the use of a wide socio-economic questionnaire. (3,4).

The gathering of basic traffic data was performed by the use of a line-scanner which was developed and specially built for this project at the Israel Ministry of Communication.

The line scanner enables the simultaneous connection to 38 telephone subscribers, and the recording of complete basic traffic information of each subscriber (see Table 1). In the same time the line scanner makes it possible to analyze the basic information according to the block diagram (Fig. 1).

A record of the basic information is fed into a computer for additional processing which converts it into traffic characteristics of the telephone subscriber.
The processed results are tabulated in ten traffic reports:

1. Outgoing calls.
2. Outgoing calls - dial tones analysing.
3. Incoming calls.
4. Individual tendencies (main directions for calls).
5. Distribution of outgoing calls.
6. Distribution of incoming calls.
7. Distribution of outgoing load.
8. Distribution of incoming load.
9. Repeated calls.
10. Distribution of repeated calls.

The traffic reports are being used as a source for the derivation of average traffic characteristic of the telephone subscribers, which are combined with socio-economic data for additional processing. Table 2 describes an example of combined results of the socio-economic survey and the traffic measurements by a line scanner. These data serve as raw material for the analysis of the traffic behaviour of the private telephone subscribers according to their socio-economic groups.

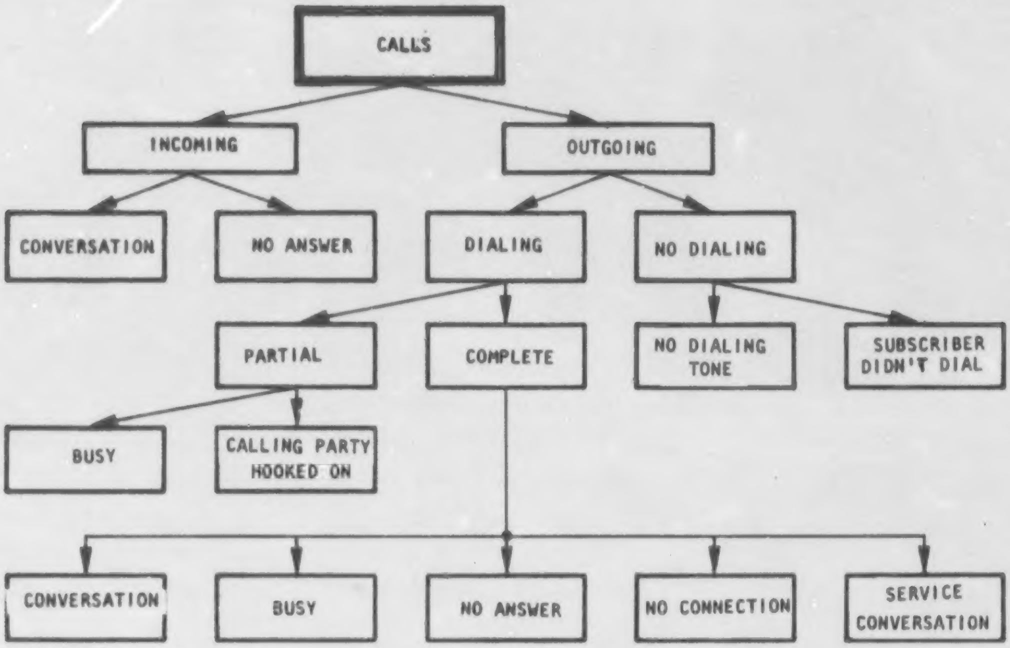
CALLS
INCOMING
OUTGOING
CONVERSATION
NO ANSWER
DIALING
NO DIALING
PARTIAL
COMPLETE
NO DIALING TONE
SUBSCRIBER DIDN'T DIAL
BUSY
CALLING PARTY HOOKED ON
CONVERSATION
BUSY
NO ANSWER
NO CONNECTION
SERVICE CONVERSATION

FIG. 1. CALL ANALYSIS USING A LINE SCANNER NUMBER OF TONES

TABLE 1

The Basic Traffic Information

No	Record	Data
1	TIME	Start time of event (hours-minutes)
2	N	Number of channel (0 - 37)
3	CD	Code of event
	11	Outgoing call - no standard error
	12	Outgoing call - ringing tones
	13	Outgoing call - busy tones
	14	Outgoing call - success
	15	Dial tone instead of ringing tones
	NO	Incoming call - no answer
	N1	Incoming call - answer
4	DIGITS	Dialled digits
5	HOLD	Hold time
6	CONV	Conversation time
7	MT	Metering pulses of incoming rings
8	TN	Number of busy or ringing tones
9	PD	Pre dial tone time
10	DT	Dial tone time
11	DL	Dial time
12	EW	Time to exchange response
13	ER	Exchange response time

3. RESULTS OF THE ANALYSIS

In accordance with the existing soci-economic structure, the sample of the private telephone subscribers was subdivided into the following four socio-economic groups:

1. Pensioners - lacking education low and very low standard or living.
2. Low level employees and skilled workers with 8 - 12 years of schoolry, medium or low standard of living.
3. High level employees of academic professions (engineers, doctors, economists etc.), medium standard of living.
4. Self-employed or high level employees, (e.g. managers, contractors etc.), high or very high standard of living.

The traffic characteristics of each socio-economic group were analysed. It was found that there exists a statistical connection between the socio-economic structure of a group of subscribers and traffic factors wich characterize it (Fig. 2)

TABLE 2

EXAMPLE OF COMBINED RESULTS OF SOCIO - ECONOMIC AND TRAFFIC FACTORS OF PRIVATE TELEPHONE SUBSCRIBERS

	SOCIO - ECONOMIC DATA							TRAFFIC DATA												
NUMBER	STATUS	PROFESSION	AGE	EDUCATION	STANDARD OF LIVING	NUMBER OF FAMILY MEMBERS	NUMBER OF METERING PULSES	OUTGOING CALLS							INCOMING CALLS					REPEATED CALLS
								NUMBER	DURATION OF CONVERS. (MIN)		NUMBER OF TONES				NUMBER	DURATION OF CONVERS (MIN)		NO. OF TONES		
											BUSY		RINGING							
									average	max	average	max	average	max		aver-age	max	aver age	max	
1	Pens.	Teach	82	Acad.	Low	2	30	6.0	4.0	18.0	5.0	22.0	8.4	13.0	4.0	5.8	34.9	3.3	9.0	6.0
2	Empl.	Clerk	52	8-12	Med.	4	150	5.3	4.9	22.0	2.7	4.0	8.0	10.0	5.0	3.2	25.4	2.5	19.0	8.0
3	Empl.	Eng.	49	Acad.	Med.	4	200	1.9	3.2	6.0	3.3	4.0	7.7	9.0	2.0	1.8	17.1	3.5	27.0	6.0
4	Self empl.	Meng.	54	Acad.	Very High	5	1608	50.1	2.6	12.0	3.4	28.0	5.8	11.0	21.0	2.4	23.5	2.7	14.0	17.0
5	Pens.	Cook	68	up to 8	Very low	2	31	0.3	10.0	10.0	-	-	-	-	1.0	5.2	10.5	3.8	5.0	2.0
6	Self Empl.	Apprais	46	8-12	Med.	4	321	18.9	2.8	25.0	5.6	50.0	5.4	12.0	7.0	3.2	31.5	2.5	9.0	87.0
7	Empl.	Techn.	53	12+	Med.	4	263	11.6	5.1	22.0	7.1	69.0	7.1	10.0	3.0	2.5	15.2	3.0	6.0	15.0
8	Empl.	Biolog	36	Acad.	Med.	4	170	6.3	3.7	22.0	6.1	37.0	10.4	19.0	3.0	18.6	133.4	4.8	39.0	30.0
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

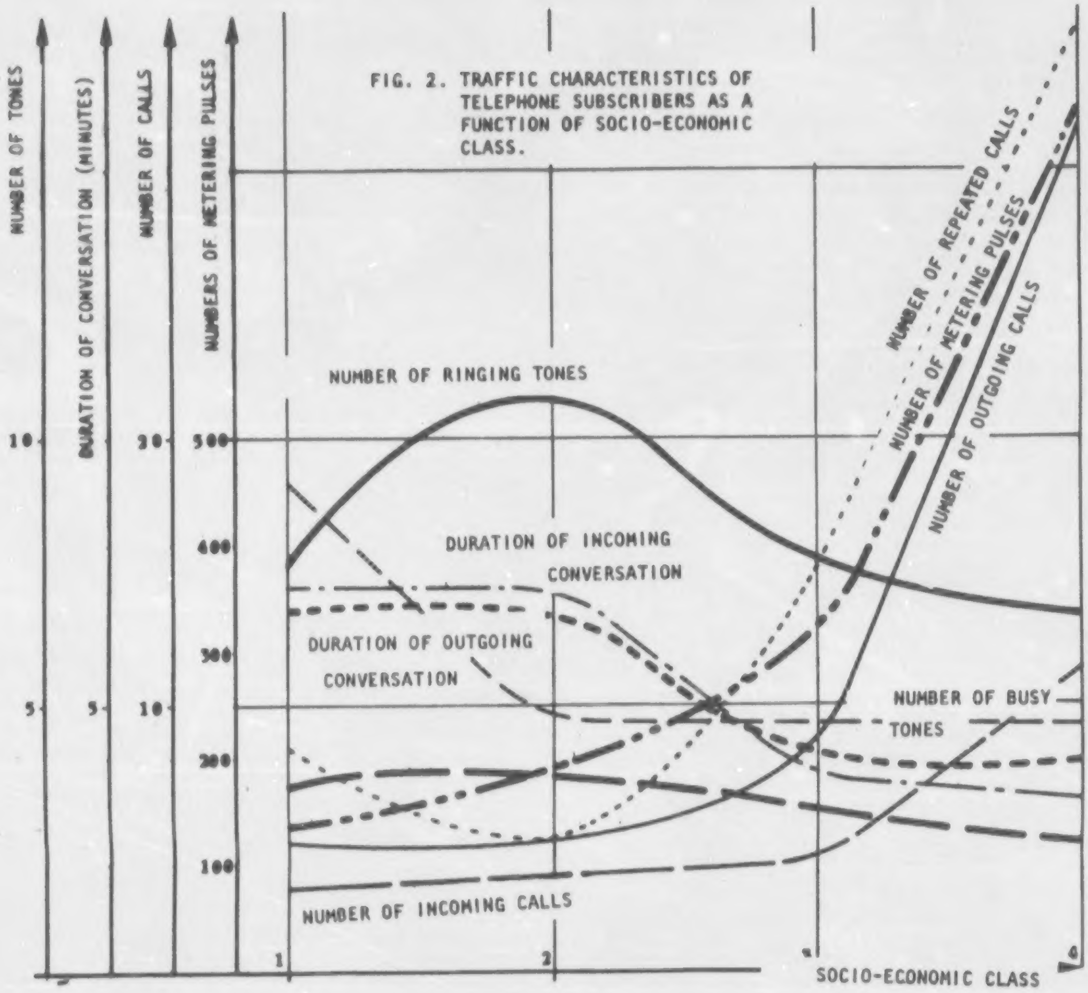

FIG. 2. TRAFFIC CHARACTERISTICS OF TELEPHONE SUBSCRIBERS AS A FUNCTION OF SOCIO-ECONOMIC CLASS.

3.1 NUMBER OF AVERAGE METERING PULSES FOR SUBSCRIBER DURING TWO MONTH PERIOD

The average bi-monthly number of metering pulses per subscriber in the entire sample was $\bar{y}_1=330$ (average number of metering pulses per subscriber in the exchange = 295).

In accordance with the change of the socio - economic structure of the subscriber group, there is a change in the average number of metering pulses which increases with the rise in status and standard of living of the subscribers (Fig. 2):

1. Pensioner - 130 metering pulses.
2. Low level employees - 190.
3. High level employees - 320.
4. Self employed or high level employees - 800.

The maximal average bi-monthly number of metering pulses equal to 1608 is found at a self-employed, contractor, 54 years old, family of 5 and a very high standard of living.

The minimal average bi-monthly number of metering pulses equal to 30 is found at a 82 years old pensioner, family of 2 and low standard of living.

3.2 NUMBER OF OUTGOING CALLS

The average number of outgoing calls per subscriber per working day in the entire sample was

$\bar{y}_2 = 10.8; \sigma_{y2} = 11.7$

The number of outgoing calls consists of successful conversational calls plus unsuccessful calls. Hence this number is not equal to the number of metering pulses, but is corresponded to it.

Similarly there is correlation between the number of outgoing calls and the socio-economic structure of subscriber groups; this number increases in accordance with the social status and standard of living of subscriber (Fig. 2).

The maximum number of outgoing calls - 50 calls per working day, is found at the same abovementioned contractor with the maximum number of metering pulses.

The minimum number of outgoing calls - 0.3 calls per working day, is found at a pensioner whose standard of living is very low.

3.3 NUMBER OF INCOMING CALLS

The average number of incoming calls per subscriber per working day in the entire sample was

$\bar{y}_3 = 5.9$; $\sigma_{y3} = 3.9$

The number of incoming calls as well as the number of metering pulses and number of outgoing calls is correlated with the socio-economic structure of the subscribers group. The number of incoming calls increases as a function of the social status and the standard of living of the subscribers (Fig 2). The maximum number of incoming calls recorded for working day was 21. This record was found at the abovementioned contractor.
The minimum number of recorded calls (1 per day) was found among several pensioners or low level employees. It should be emphasized that there is a definite relation between the number of incoming and outgoing calls (Fig. 3).

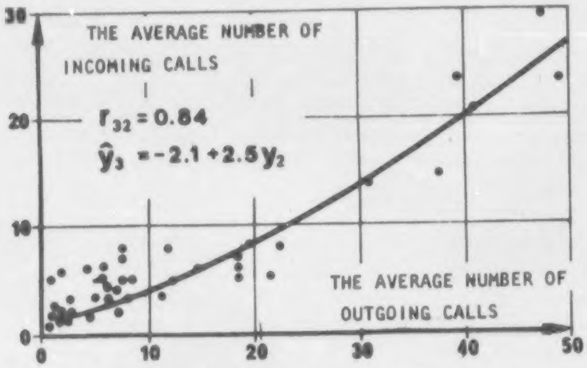

FIG. 3 AVERAGE NUMBER OF INCOMING CALLS AS A FUNCTION OF AVERAGE NUMBER OF OUTGOING CALLS.

It appears that a private subscriber who does not generate calls doesn't also receive calls.
It may be concluded that the number of incoming calls of private subscriber is usually lower than the number of outgoing calls by about a factor of 2.
This result may be explained by the fact that only about one-half of the calls of the private subscriber are directed to other private subscribers (relatives, friends etc...). The second half is directed to various institutions and services. However these establishments, don't generally generate calls to private subscribers and this results in a decrease in the part of the incoming calls of the total balance of calls of the private subscriber.
An additional conclusion which may be derived from this analysis is that a small or zero subscriber who does not place more than 2-5 calls per day, does not generally contact the establishments. In this case the number of outgoing calls is approximately equal to the number of incoming calls.

3.4 DURATION OF AN OUTGOING CONVERSATION

The average duration of an outgoing conversation per subscriber per working day in the entire sample was

$$\bar{y}_4 = 5.0 \text{ min}; \ \sigma_{y4} = 4.0$$

It should be emphasized that there is a definite relation between the duration of an outgoing conversation and the socio-economic characteristics of the telephone subscriber (Fig. 2).
The distribution of the duration is as follows:

1. Up to 3 minute - self employed, or high level employees - managers, contractors, insurance agents, etc. (high or very high standard of living).
2. Between 3 to 5 minute - employees of academic professions - engineers, doctors, etc... (medium standard of living).
3. Over 5 minute - pensioners, minimal education (low and very low standard of living).

The maximum duration of outgoing conversation, of about 2 hours, during working days was found among several subscribers (skilled workers, pensioners, etc.). It is obvious, that the duration of an outgoing conversation of the private subscriber is strongly depended on the average number of outgoing calls of the same subscriber.
It appears that a private subscriber, who places a small number of outgoing calls, is generally engaged in longer conversations.

The average duration of a conversation of a small or zero subscriber, who does not place more than one call per day, is approximately equal to 10 min. As the number of calls increases there is a decrease in the call durations. For instance:

- for a subscriber having 5 to 10 daily calls the average call duration is 4.5 minutes;
- for a subscriber having 10 to 12 daily calls the average is 3.7 minutes.

A further increase in the number of calls doesn't have a significant influence on the average of call duration and it appears that for any number of calls the average duration is between 3 to 2 minutes.

3.5 DURATION OF AN INCOMING CONVERSATION

The average duration of an incoming conversation per subscriber per working day was found to be equal to the outgoing conversation and was $\bar{y}_5 = \bar{y}_4 = 5$ minutes.

There is some difinite relation between the duration of an incoming conversation and the socio-economic characteristics of the telephone subscriber (Fig. 2). The maximum duration of the incoming conversations of two hours, was found equal to the maximum duration of an outgoing conversation.

It should be emphasized that this equality doesn't exist when the duration of the conversation is short (up to 5 minutes). In such a case the duration of the incoming conversation is longer than the duration of the outgoing conversation.

The explanation of this is that outgoing conversations comprise, in addition to social contacts also of dealing with various organizations. The incoming conversations, in comparison, are usually social and therefore are longer.

3.6 THE NUMBER OF BUSY TONES

Usually a subscriber doesn't hook on immediately after receiving a busy tone. The average number of busy tones up to the execution of "hook on" per subscriber per working day was: $\bar{y}_6=5.5$, $\sigma_6 = 3.6$. The maximum recorded number was 93 and it is suprising in view of the fact that hearing busy tones is a waste of time.

The average number of busy tones is correlated with the average number of outgoing calls (Fig. 4).

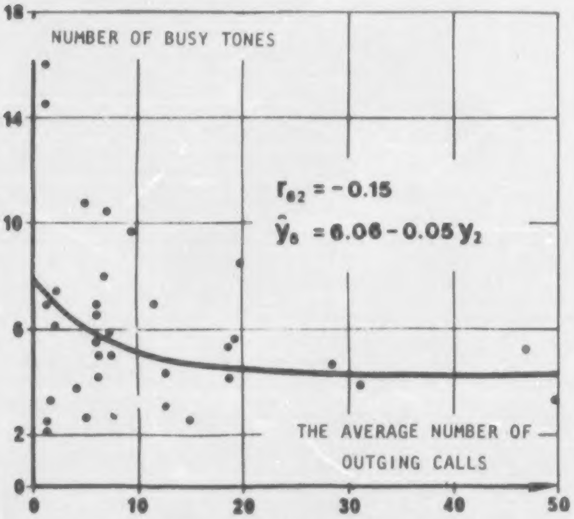

FIG. 4 AVERAGE NUMBER OF BUSY TONES AS A FUNCTION OF AVERAGE NUMBER OF OUTGOING CALLS.

It may be seen that a subscriber having a higher number of calls usually accepts less busy tones because he is more knowledgable of the system. For instance, for the socio-economic group 1 $\bar{y}_6 = 9.2$. Then, this number quickly decreases for higher socio-economic groups and reaches an average of 4,5 tones

Asurprising phenomenon founded was that subscribers accepting the maximum number of busy tones (between 30to 93) belong to different socio-economic groups andmay be even young people with academic background. The maximum number of accepted busy tones recorded was found for an educated middle age employee with a very high standard of living (1150 bi-monthly metering pulses).

3.7 NUMBER OF RINGING TONES FOR AN OUTGOING CALL

In case there is no answer on the line, the calling subscriber continues to listen to a number of ringing tones until he is convinced that no reply is forthcoming. The average recorded number of ringing tones heard by the calling subscriber was $\bar{y}_7 = 7.8$ $\sigma_{y7} = 2.0$
The maximum recorded number of ringing tones was 32. It was found that there is a relation between the average number of ringing tones up to "hook up" and the socio-economic group to which the subscriber belongs (Fig 2).
Furthermore there exists a relation between the maximum number of busy tones and the maximum number of ringing tones (Fig. 5).
It seems that a subscriber who generally listens to numerous busy tones, also listens to many ringing tones.

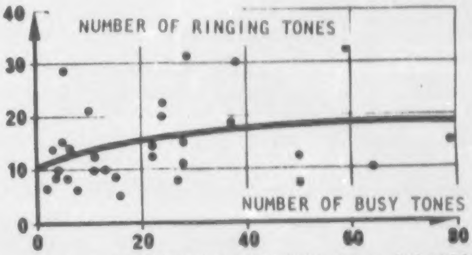

FIG. 5 LISTENNING REACTION OF A SUBSCRIBER TO RINGING TONES AS A FUNCTION OF HIS REACTION TO BUSY TONES.

3.8 NUMBER OF RINGING TONES FOR AN INCOMING CALL

The number of ringing tones prior to answereing the incoming calls was in avereage $\bar{y}_8=3.0$, $\sigma_{y8} = 0.9$.
A relation was found between the average number of ringing tones and the socio-economic groups of the subscribers (Fig. 2).
It seems that usually older and uneducated subscribers hear more ringing tones up to their hook off. The maximum recorded number for this groups was 39 (average 3.7).
The relation between the number of ringing tones and the number of incoming calls is stressed in Fig. 6.

3.9 REPEATED CALLS

In event that a calling subscriber doesn't achieve a conversation (busy or other) he usually repeats his call in series. The numbers of calls in such a serie recorded were: $\bar{y}_9=15.6$, $\sigma_{y9}=17.3$, $y_9^{max} = 87$.

It was found out that after receiving busy tones a calling subscriber usually repeats up to 9.0 his calling, while receiving no answer the repeating calls number is up to 6.0

There is a relationship between the number of repeated calls of telephone subscriber and the socio-economic group to which he belongs(Fig. 2).

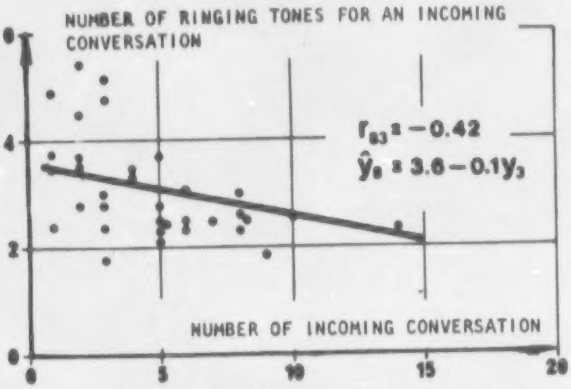

FIG. 6 NUMBER OF RINGING TONES FOR AN INCOMING CONVERSATION AS A FUNCTION OF THE NUMBER OF INCOMING CALLS (DAILY AVERAGE).

Furthermore a relation may also be established between the number of outgoing calls and the repeated calls series (Fig.7).

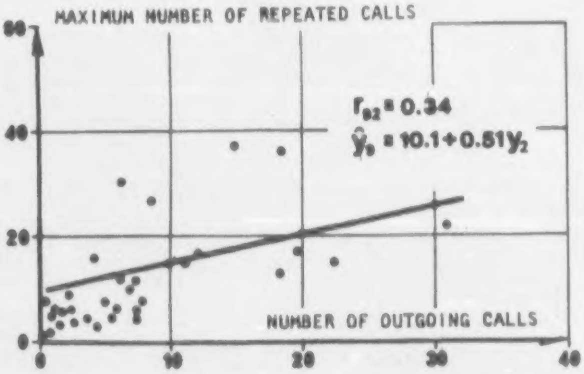

FIG. 7 MAXIMUM OF REPEATED CALLS IN DAILY SERIES AS FUNCTION OF THE AVERAGE NUMBER OF OUTGOING CALLS.

4. SUMMARY

In this work a preliminary attempt was made to study the traffic behaviour of Israeli private telephone subsribers through the introduction of socio-economic aspects.

It was found that there exists a statistical connection between the traffic behaviour of telephone subscribers and the socio-economic structure of a group to which they belong.

The results of this study may lead to some system planning improvement, greater service efficiency and its adjustment to subscriber requirements.

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Data Communications
From The User's Viewpoint

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INTRODUCTION

This presentation provides a basic understanding of data communications. It is developed to impart a working knowledge of the subject to permit wiser equipment evaluation and operation.

Data communications is a big business today. But with the number of devices available and their growing user base, an understanding of these products and functions can mean dollars and cents to those involved.

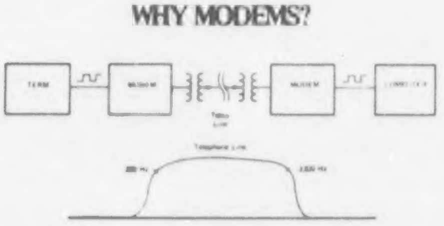

WHY MODEMS?
TERM
MODEM
MODEM
Telephone Line

FIGURE 1

WHY MODEMS?

Modem is a contraction of the terms Modulator - Demodulator. The telephone system is designed to handle voice communications in a frequency range of 300 cycles per second (H2) to 3300 H2. Since we are attempting to transmit data (or digital signals) thru that telephone system, signals must be conditioned to operate in the environment designed for voice.

The logical reason for using the telephone system for transmission of data is that it reaches nearly every point in the world.

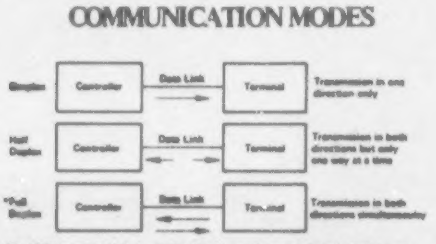

COMMUNICATION MODES
Simplex
Controller
Data Link
Terminal
Transmission in one direction only
Half Duplex
Controller
Data Link
Terminal
Transmission in both directions but only one way at a time
*Full Duplex
Controller
Data Link
Terminal
Transmission in both directions simultaneously
*Per ASCII standard full duplex implies that the same data rate exists in both directions simultaneously, i.e., 1200/150 bps is not full duplex. 1200/1200 bps is full duplex.

FIGURE 2

Terminology is always a problem for a neophyte in any field, and is a security blanket for the establishment. This presentation is designed to clarify the confusion presented by the terms associated with data communications.

Quite simply, in data communications jargon, simplex means broadcast - very much like a TV station broadcasts to a receiver in your home. The station sends out the signal blindly, expecting no response at all; of course, your receiver must be tuned to the proper channel to receive the transmission.

Half duplex is similar to two Ham radio operators who state "over" at the end of each transmission so that the receiving party (or terminal) "recognizes" they may begin transmission. Their sequence is called a communication PROTOCOL.

With modems, signals called RTS (Request To Send) and CTS (Clear To Send) are generated from the terminal and computer to determine which unit can transmit. A key thing to remember is that Half Duplex communication is strictly ONE WAY at any time. Full Duplex means that both ends can transmit and receive simultaneously. Full Duplex also infers that the data rate in each direction is identical.

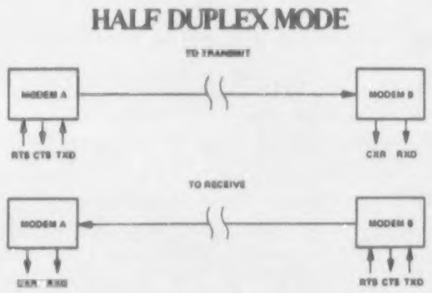

HALF DUPLEX MODE
TO TRANSMIT
MODEM A
MODEM B
RTS CTS TXD
CXR RXD
TO RECEIVE
MODEM A
MODEM B
CXR RXD
RTS CTS TXD

FIGURE 3

Again, talking about half duplex--if modem A wants to transmit to modem B the terminal or computer associated with modem A must raise a signal in it's interface called Request to Send (RTS), which is similar to "over" for the Ham operator, only it is at the beginning rather than the end of the transmission. The system protocol and software determine what the individual characteristics are for any specific installations.

From the Users standpoint, be certain that the terminal, computer, and everything between can support the "Request to Send - Clear to Send" handshake if you plan to or are using "half duplex" modems. These would be equivalent to the Bell 202, 201, 208, or 209 types.

FULL DUPLEX MODE

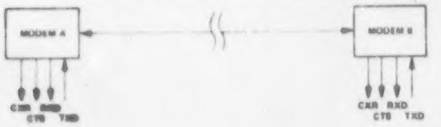

MODEM A
MODEM B
CXR
RXD
CTS
TXD
CXR
RXD
CTS
TXD

FIGURE 4

Full Duplex, as was mentioned, means simultaneous bi-directional communications. In data communications, it means that the modem is essentially invisible to the link between the terminal and the computer.

Full Duplex in data communications terminology means that the link between the terminal and computer is totally transparent -- as if the terminal was "hardwired" to the cpu.

TERMINAL TERMINOLOGY

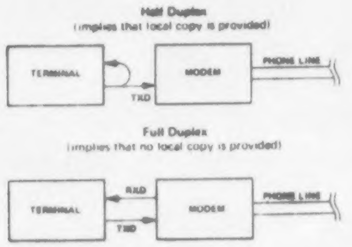

Half Duplex
(implies that local copy is provided)
TERMINAL
MODEM
PHONE LINE
TXD
Full Duplex
(implies that no local copy is provided)
TERMINAL
MODEM
PHONE LINE
RXD
TXD

FIGURE 5

Why the concern for terminology? There is a switch on most terminals labeled Half Duplex (or Local Copy) vs Full Duplex (Possibly "Echo").

In "terminal terminology", the terms previously discussed under modems have a totally different meaning.

In a terminal - the half duplex (local copy) mode means that the character generated by a key stroke is sent to the display (CRT or printer) and to the modem (or computer) at the same time.

Full duplex mode with a terminal means that the character is sent to the computer and is echo'ed back before being displayed.

There is a reason for this important distinction!

Most Minicomputers were constructed to work with local terminals. If a terminal is directly connected to a computer, few errors in transmission/reception can result; but as soon as modems and the telephone lines are used errors can occur.

The most rudimentary form of error detection is the operator seeing if the character displayed is the same as a keystroke. Full duplex - echoplex operation provides this feedback.

Bear in mind that the terms Half and Full Duplex have different meanings for terminals vs modems.

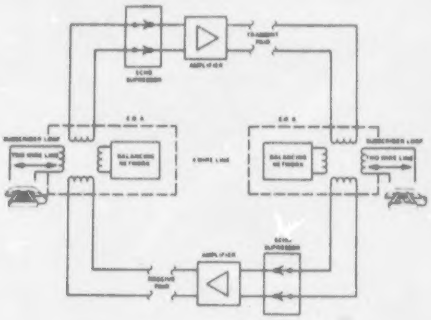

ECHO SUPPRESSOR
AMPLIFIER
TRANSMIT PAIR
C.O. A
C.O. B
SUBSCRIBER LOOP
TWO WIRE LINE
BALANCING NETWORK
4 WIRE LINE
BALANCING NETWORK
SUBSCRIBER LOOP
TWO WIRE LINE
AMPLIFIER
ECHO SUPPRESSOR
RECEIVE PAIR

FIGURE 6

Some understanding of the telephone network is important to make the proper selection of modems.

The telephone line from your location to the telephone company's central office is called a subscriber loop. The subscriber loops are made up of a pair of wires (two wire circuit.) At the central office, the pair is run thru a "Hybrid" circuit that splits traffic into transmit and receive pairs between central offices.

Notice on the diagram that amplifiers and echo supressors exist in the circuit which allow traffic to flow only in one direction on that wire pair. Another circuit component not shown on the diagram is a loading coil. Remember that the telephone system was designed to pass voice frequencies (300 H2 to 3300 H2) and any modems must live with this frequency bandwith constraint. We will discuss various types of Bell compatible modems and Line Drivers which offer better cost/performance for limited distance applications, that may require other than normal 3002 specification voice grade lines.

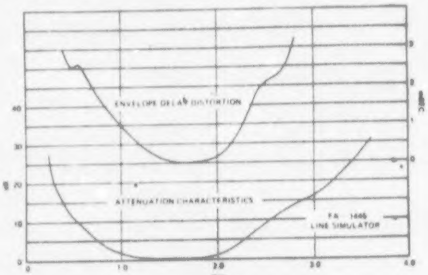


FIGURE 7

Envelope delay distortion and attenuation vs frequency are more important to the modem designer than to the end user. A discussion of these parameters provides some understanding of the problems that arise when the modems attempt to use frequencies near the extreme edges of the 300-3300Hz voice bandwith.

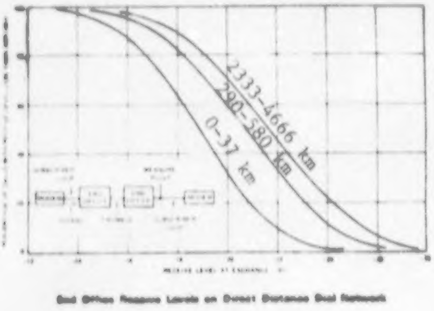


FIGURE 8

Sometimes when using the telephone, a call must be re-dialed because of noise, cross-talk, or echo's on the line. When this happens, the odds are good that the re-try will produce a better line. With modems in the dial-up environment, the same thing can happen.

Figure 8 shows the probability of getting a connection with receive levels that fall within the operating limits of the modems. "Dedicated" or leased lines are different from a dial circuit in that the telephone company (Telco) sets up a relatively permanent connection that is tested during installation to insure signal quality.

Whether to run your terminals via dial-up or leased lines is purely an economic decision and involves comparing toll charges to monthly lease rates. A leased line will average $4.00 per mile per month. Dial tolls for long distance calls can be calculated right out of the front of your phone book, but few users realize the impact of SMRUT (Single Message Rate Unit Timing) which gives the phone company a penny per minute on local calls over 5 minutes connect time. If you dial your "local" computer and stay connected for a normal 8 hour day, the monthly toll charge will be just over $100. A leased line would have cost only $14-$20, and be available 24 hours per day.

BELL 103/113

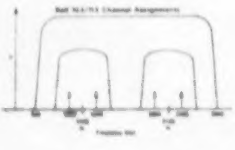


FIGURE 9

The 103 type modem is the most common device to be found in use. All time-shared computer services offer 0-30 character/second (0-300 bits/sec) service using 103 type modems. It is a full duplex modem using two "sub-carriers" within the telephone bandwith.

Two areas of confusion exist with 103 type modems: (1) The 103 has the ability to automatically switch from the "originate" mode to the "answer" mode upon detection of a Ring signal. Whereas the 113 A is "originate" only and the 113 B is "answer" only; (2) The terms originate and answer relate only to the frequencies modems use for transmit and receive--not to who starts or receives the call.

DIAL-UP

103A2 or A3
(Latest version introduced Nov. 1976 designated 103J)
Originate/answer
Single channel – self contained
$25 to $35/month

103E Data Station – Computer Site
Originate/answer
40 channels max
$25 to $35/month

113A Terminal Data Set
Originate only
Single channel – self contained
$10 to $15/month

113B Data Station – Computer Site
Answer only
20 channel increments – 120 max.
$12 to $20/month Average $16 to $18

LEASED LINE

103F
Originate/answer
Single channel – self contained
$25 to $35/month

FIGURE 10

Pricing varies depending on the specific telephone company, but this shows the average charge to expect. An equivalent/Bell compatible modem from an independent supplier can be purchased for about $375.00. Quick calculations show that buying vs renting will pay off within as short a time as ten months.

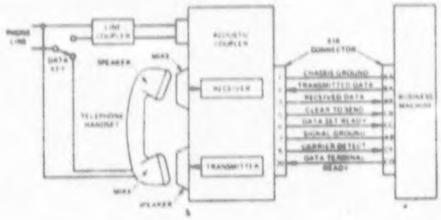


FIGURE 11

Acoustic couplers have become very popular, as they allow portability of the terminal and modem. Any telephone can be utilized as a data input station. However, there is a real disadvantage to the acoustic coupler.

The modem transmit or received level must be downgraded to reduce undesireable second harmonic signals from the originate mode transmitter feeding back through the telephone hand set to the modem receiver. The net effect is that long distance transmission via acoustically coupled modems usually will exhibit more errors than a hardwired modem connection.

Acoustically coupled modems in the past have been limited to 103 compatible units at 300 bits/sec full duplex or 202 compatible units at 1200 bps half duplex. Very recently, full duplex 1200 bps full duplex acoustic couplers became available.

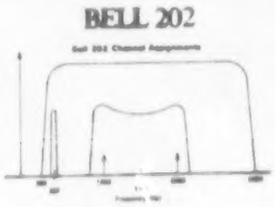


FIGURE 12

The 202 type modems are 0-1200 bps half duplex devices when used in a dial-up application. They require that the terminal and computer be able to control and recognize The Request To Send/Clear To Send half duplex protocol. Most mini-computers and simple terminals do not have the ability to recognize these signals. Characters can only be transmitted in one direction at a time, and the 202 becomes totally useless in the typical interactive mini-computer based system. They fit very well in Point-of-sale systems where traffic is essentially undirectional.

Some people recommend "reverse channel" operation with a 202 to provide feedback in the other direction while transmitting. "Paper Out" indication from a printer would be a logical example of the kind of low data rate (5 bps) information that could be transmitted reverse channel. However, as noted in the attenuation curve in figure 7, the relationship of the 387 hz carrier of the reverse channel signal to the rising attentuation in the lowest part of the telephone bandwith emphasizes the reason reverse channel use is not recommended.

Where the 202's really perform is in the 4-wire dedicated/leased line applications where the transmitter at one end is connected to the receiver at the other on one pair and vice versa.

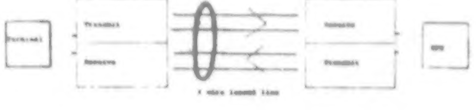


FIGURE 13

Costs for 202 type modems are fairly low. Even here, independent suppliers can save you significant amounts on your purchase vs rent. The typical purchase price of a 202 compatible device is $450.00

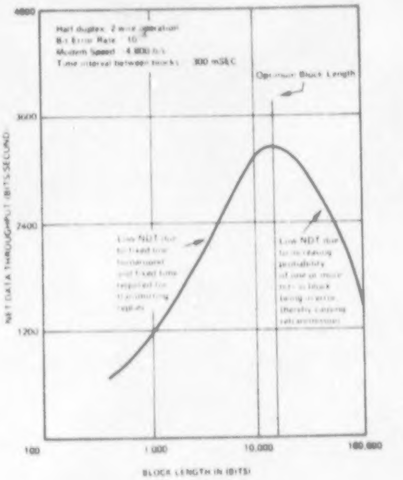


FIGURE 14

Net data throughput can be the subject of an entire book. The point of discussing it here is that in sophisticated Half duplex systems some form of error detection and retransmission exists. Higher speed modems have higher error rates.

Telephone systems have error rates due to crosstalk, impulse noise, drop-outs, and so on.

Data is formatted into blocks at the transmitter and sent down the line. If the data is received correctly, the receiving end sends back a short message saying "OK". Each time the line is "turned around" via RTS/CTS so one end can send, turnaround delays occur due to the nature of the telephone system. Typically a 200 millisecond delay occurs with each turnaround. The initial part of this curve shows low net data thruput due to the effect of the turn around delays. As block length goes past the "optimum", longer error in the block resulting in retransmission of the entire block, resulting in rapid degradation of throughput past the "optimum" block size. The book says how to calculate optimum block size. But any half duplex modem will have lower thruput than a full duplex modem at the same speed.

VA3400 SPECIFICATIONS

Data:
Serial, binary, asynchronous or synchronous, full duplex

Data Rate:
1200 bps asynchronous/synchronous or any speed 0 to 300 bps
600 bps asynchronous/synchronous or any speed 0 to 150 bps

(figure continued)

Mode:
Full duplex on dial up or 2-wire leased lines

Modulation:
Dibit phase shift keyed (DPSK)

Transmit Level:
0 to −14 dBm

Receive Level:
−15 to −50 dBm (or 0 to −35 dBm) simultaneous
with adjacent channel transmitter at up to 0 dBm

Channel Assignment:

	ORIGINATING END	ANSWERING END
Transmit	Fc = 2250 Hz	Fc = 1150 Hz
Receive	Fc = 1150 Hz	Fc = 2250 Hz

FIGURE 15

As an example of what can be accomplished by independent supplier, VADIC introduced the 1200 bps full duplex modem 8 years ago. It had the same digital (RS-232) interface as the Bell 103/113 and allowed users to upgrade from 300 bps to 1200 bps by changing modems and turning the speed select switch of their terminal and computer.

BELL 212A SPECIFICATIONS

Data:
Serial, binary, asynchronous or synchronous full duplex

Data Rate:
1200 bps asynchronous or synchronous
0 to 300 bps asynchronous via FSK 103

Mode:
Full duplex on dial up lines

Modulation:
1200 bps – Dibit phase shift keyed (DPSK)
300 bps – Frequency shift keyed (FSK)

Channel Assignment:

	ORIGINATING END	ANSWERING END
Transmit	Fc = 1200 Hz	Fc = 2400 Hz
Receive	Fc = 2400 Hz	Fc = 1200 Hz

Phase Shift:

DIBIT	212A
00	90°
01	0°
10	180°
11	270°

FSK Frequencies:

	ORIGINATING END	ANSWERING END
Transmit	1070 Hz Space 1270 Hz Mark	2025 Hz Space 2225 Hz Mark
Receive	2025 Hz Space 2225 Hz Mark	1070 Hz Space 1270 Hz Mark

FIGURE 16

Two years ago, Bell introduced the 212 to do the same thing. The features are similar, but note that Bell stayed with "transmit low-receive high" at the originate side, which because of second harmonic related problems makes the development of an acoustically coupled 212 very difficult - if not impossible.

VADIC 3400 BLOCK DIAGRAM

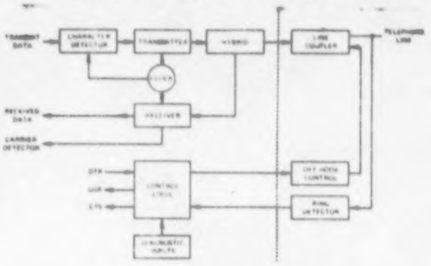


FIGURE 17

BELL 212A

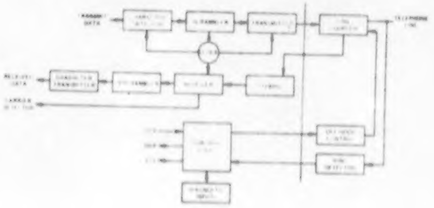


FIGURE 18

VADIC's and Bell's technique in other respects are extremely similar as these two block diagrams illustrate. And the independent has done it again: Bell compatibility with both 212 and 103, plus the ability to communicate with their proprietary product line which includes an acoustic 1200 bps full duplex.

An interesting point to make is that both of these 1200 bps full duplex modems changed modulation schemes from a conventional frequency shift keyed (FSK) modulation to Di-bit Phase shift keyed (DPSK) modulation where bit pairs are encoded into a single phase shift for transmission. Even though the modems appear to be asychronous to the outside world, their transmission and data recovery is synchronous--yielding a lower error rate than the Bell 103

VA3467 TRIPLE MODEM

The VA3467 embodies a VA3400 compatible modem, a Bell 212A compatible modem, and a Bell 103 compatible modem, all in answer mode. It features an automatic recognition sequence that identifies a calling modem (presuming it's a 3400, 212A or 103) without disturbing normal connect protocols for any specific modem; computer service operators will not have to retrain customers or users on proper dial-in disciplines. Terminal interface operation is also transparent to actual modem type used; computers capable of using the, VA3400 or Bell 212A can use the VA3467 without altering hardware or software.

FIGURE 19

As we go above 1200 bps into the synchronous world of 2400 bps and above, the requirements of the terminal and computer are changed. They must be able to be synchronized to the modem "clock" and must be able to accommodate the "handshaking" of RTS/CTS required by half duplex modems -- as everything in the Bell world at 2400 bps and above is synchronous half duplex.

The 201 family pricing is noticeably higher than the lower speed units - because they are more complex. Again, independent suppliers offer significant long-term savings at approximately $625/unit.

BELL HIGH SPEED

201A: 2000 BPS; Single channel, self contained; Dial-up; $55 leased; $70 dial-up

201B: 2400 BPS; Single channel, self contained; leased lines, $55 leased; $70 dial-up

201C: 2400 BPS; Single channel or up to 6, 12 or 30; In common cabinet; Dial-up or leased line; $55 leased; $70 dial-up

FIGURE 20

The 201 is another example of bit pairing where the modulation rate is reduced on the analog side of the line. Terminology, again has been confused. Many people in the business indiscriminately interchange Bits/Sec and Baud rate. Wrong! Bits/Sec have to do with the input from the terminal (or CPU) to the modem's digital side. Baud Rate is the rate of change of the signalling element on the analog output side of the modem. If we input 2400 bits/sec into a dibit PSK modem, the output will be 1200 baud. The terms shouldn't be interchanged.

BELL 201B/C

Bell 201 modems are 2400 bps synchronous half duplex 2-wire or full duplex 4-wire units that use a modulation scheme similar to the VADIC VA3400. The 201A is an obsolete 2000 bps modem. The 201B is for private or leased line applications, and the 201C is for dial up applications.

SPECIFICATIONS

Data: Serial, binary, synchronous, half duplex on 2 wire lines

Data Transfer Rate 2400 bps

Modulation: Dibit Phase Shift Keying (DPSK)

Transmit Level: 0 to -14 dBm

Receive Level 15 dBm to -50 dBm or 0 dBm to -35 dBm

RTS/CTS Delay: 0, 7.5 msec, or 150 msec

PHASE SHIFT

Dibit	201B/C	201A
00	45°	0°
01	135°	90°
11	225°	180°
10	315°	270°

Note: 201A 2000 bps dial up lines replaced by 201C.

FIGURE 21

The higher speed modems combine even more bits per baud, and costs increase at a dramatic rate. In configuring a system, keep modem costs vs speed in mind to keep overall system cost down.

REPLACING BELL MODEMS

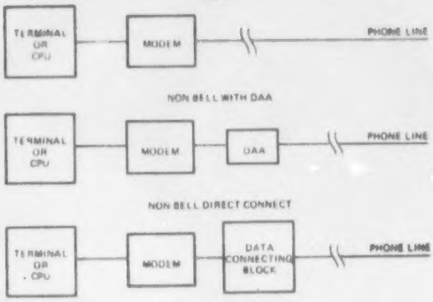


FIGURE 22

When replacing Bell modems to reduce network cost, be sure to provide a Data Access Arrangement (DAA) in order to honor telephone company rules. Bell modems contain the required circuitry. Early independent modems required an external DAA provided by the phone companies. Present day modems contain the necessary circuitry and are certified by the F.C.C. for "direct connect".

Typical Automatic DAA Configuration

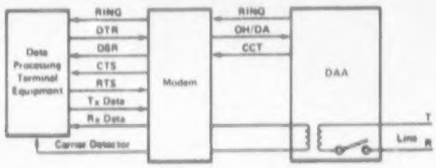
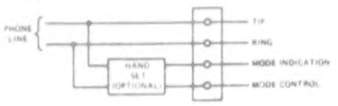


FIGURE 23

Primarily, the DAA function is necessary because it transfers the line from phone to modem at the calling end. At the answering end, the DAA conditions and passes the ring signal to the modem. If "Data Terminal Ready" is present on the modem's terminal interface, the modem will tell the DAA to go off hook and answer the incoming call. The DAA waits approximately a second after answering to allow the central office billing equipment to record call completion. Another important function of the DAA is protection of the modem (and terminal user) from high voltage surges that may appear on the phone line.

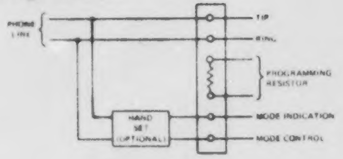
DATA JACKS

Permissive



(figure continued)

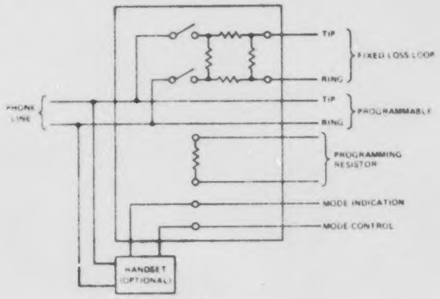
97B Programmable



PHONE LINE
TIP
RING
PROGRAMMING RESISTOR
HAND SET (OPTIONAL)
MODE INDICATION
MODE CONTROL

FIGURE 24

97A Universal Data Jack-Fixed Loss/Programmable



TIP
RING
FIXED LOSS LOOP
PHONE LINE
TIP
RING
PROGRAMMABLE
PROGRAMMING RESISTOR
MODE INDICATION
MODE CONTROL
HANDSET (OPTIONAL)

FIGURE 25

Data jacks are now required by the phone company to interface "direct connect" modems. Various types of jacks are used depending on availability modem certification and application.

CCITT MODEMS AND RECOMMENDATIONS

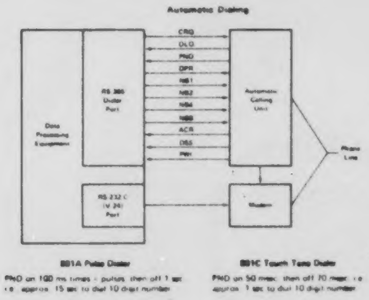
V.21	0 to 200 (300) bps (similar to Bell 103) Defined for FDX switched network operation
V.23	600/1200 bps (similar to Bell 202). Defined for HDX switched network operation. 75 bps channel optional
V.24	Definition of interchange circuits (similar to EIA RS232C)
V.25	Automatic calling and/or answering units (similar to Bell 801)
V.26	2400 bps (identical to Bell 201B). Defined for 4-wire leased circuits
V.26 bis	2400/1200 bps (similar to Bell 201C). Defined for switched network
V.27	4800 bps (similar to Bell 208A). Defined for leased circuits using manual equalizers
V.27 bis	4800 bps modem for leased circuits with automatic equalizer
V.27 ter	4800/2400 bps modem for switched network operation
V.28	**Electrical characteristics for interchange circuits (similar to RS232C)**
V.29	**9600 bps modem for leased circuits**

FIGURE 26

CCITT Modems are used in other countries and are discussed only to create awareness that the modems in Mexico or France may not "talk" to yours.

Line Drivers, Limited Distance Modems, or Short Haul Modems (see FIGURE 27) are relatively new defices that can significantly reduce costs if requirements fit their limitations. They are only useful on dedicated lines - cannot be used for dial-up applications. The savings to be realized are phenominal if the transmission distance is known to be short.

BELL 801

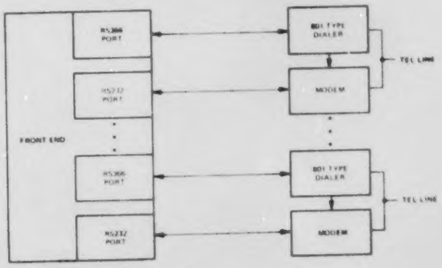


Automatic Dialing
Data Processing Equipment
RS 366 Dialer Port
CRQ
DLO
PND
DPR
NB1
NB2
NB4
NB8
ACR
DSS
PWI
Automatic Calling Unit
Phone Line
RS 232 C (V 24) Port
Modem
801A Pulse Dialer
PND on 100 ms times = pulses then off 1 sec i.e. approx. 15 sec to dial 10 digit number
801C Touch Tone Dialer
PND on 50 msec then off 70 msec i.e. approx. 1 sec to dial 10 digit number

FIGURE 28

All this talk about modems is followed by some interesting approaches to efficiency cost reduction in different ways. Having a computer able to automatically dial remote sites where data is stored is a good way to get data in from those remote sites between 6 p.m. and 8 a.m. when the phone rates are low -- and without people being involved.

The Bell 801 auto dialer is interfaced to a computer via a parallel interface (EIA Spec. RS 366) supported by most large computers, some medium size computers, and very few minicomputers. The RS 366 interface on a large computer may cost $1500/dialer. On a medium sized computer it may run $800. A mini probably has to make do with it's RS 232 ports.



FRONT END
RS366 PORT
RS232 PORT
RS366 PORT
RS232 PORT
801 TYPE DIALER
MODEM
801 TYPE DIALER
MODEM
TEL LINE
TEL LINE

FIGURE 29

In a conventional 801 auto dialer application, the RS 366 interface is connected to the dialer; an RS 232 interface is connected to the modem associated to the dialer. A telephone line is controlled by this dialer/modem combination.

The CPU tells the dialer the number to call. After the connection is made, the dialer hands

FULL DUPLEX DEDICATED LINE MODEMS

MODEM TYPE	DISTANCE	4-WIRE CIRCUIT TYPE	ASYNC	SYNC	SPEED (bps)	PURCHASE COST/END
Line Driver	0-5 miles	dc Continuity	X		0-19,200	$ 200
Limited Distance	0-5 miles	Non-Loaded, Non-Amplified	X		0- 9,600	$ 300
Limited Distance	0-5 miles	Non-Loaded, Non-Amplified		X	2,400-4,800 9,600-19,200	$ 775
Limited Distance	0-5 miles	Non-Loaded, Non-Amplified or 50 ohm coaxial cable		X	40.8, 48, 50 56,230.4kbps	$1,050
Limited Distance	0-2 miles	Non-Loaded, Non-Amplified or 50 ohm coaxial cable		X	230.4k to 1.544Mbps	$3,750
Short Haul	0-5 miles	Voice Grade (3002)	X		0-4,800	$ 500
Short Haul	0-50 miles	Voice Grade (3002)		X	4,800	$1,350
Short Haul	0-50 miles	Voice Grade (3002)	X		0-4,800	$1,500
202	Unlimited	Voice Grade (3002)	X		0-1,800	$ 450
201	Unlimited	Voice Grade (3002)		X	2,400	$ 625
208	Unlimited	Voice Grade (3002)		X	4,800	$3,000
209	Unlimited	Voice Grade (3002)		X	9,600	$4,500
303	Unlimited	Special facilities at $15/mile/month		X	19.2 to 230.4kpbs	$ 450 to 700/mo. (rental only)
Fiber Optic	0-3,000 feet without repeaters	Fiber optic cable from $0.95/foot	X	X	0 to 56kbps	$ 700
Fiber Optic	0-3,000 feet without repeaters	Fiber optic cable from $0.95/foot		X	0-2mbps	$1,500

FIGURE 27

over the telephone line to it's associated modem and transmission begins.

SYSTEM WITH RS232 TO RS366 ADAPTER

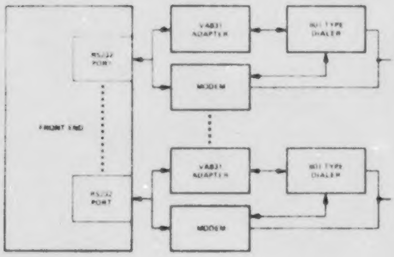

RS232 PORT
FRONT END
RS232 PORT
VA831 ADAPTER
801 TYPE DIALER
MODEM
TEL LINE
VA831 ADAPTER
801 TYPE DIALER
MODEM
TEL LINE

FIGURE 30

What about the person who buys a computer that only supports RS 232 serial interfaces? Again, the independent's come to the rescue by providing an RS 232 to RS 366 adaptor. The same outdialing routine is involved except that it is thru the low cost interface.

MACS BLOCK DIAGRAM

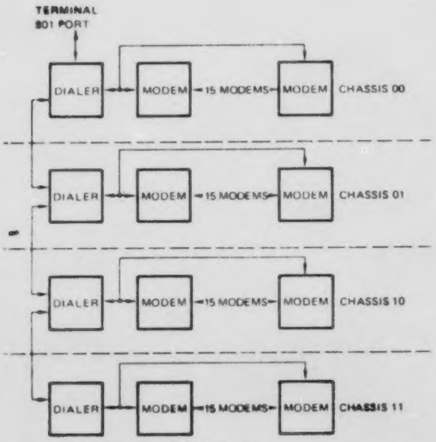
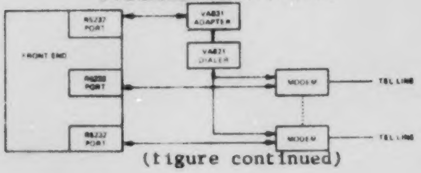

TERMINAL
801 PORT
DIALER
MODEM
15 MODEMS
MODEM
CHASSIS 00
DIALER
MODEM
15 MODEMS
MODEM
CHASSIS 01
DIALER
MODEM
15 MODEMS
MODEM
CHASSIS 10
DIALER
MODEM
15 MODEMS
MODEM
CHASSIS 11

FIGURE 31

For high traffic applications like Ford or General Motors updating dealer parts inventories around the country overnite, a multi-line Automatic Calling System may be indicated. This approach lets one dialer support up to 15 modems and lines.

SYSTEM USING VA821 MULTILINE DIALER


RS232 PORT
FRONT END
RS232 PORT
RS232 PORT
VA831 ADAPTER
VA821 DIALER
MODEM
TEL LINE
MODEM
TEL LINE

(figure continued)

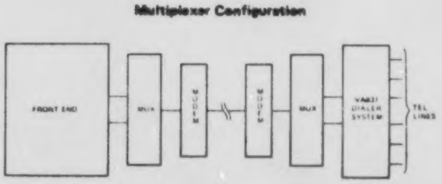

Multiplexer Configuration
FRONT END
MUX
MODEM
MODEM
MUX
VA831 DIALER SYSTEM
TEL LINES

FIGURE 32

With the RS 232 adaptor, dialers can be put at the "tail-end" of multiplexed data links to do remote dialing in a remote "local" exchange.

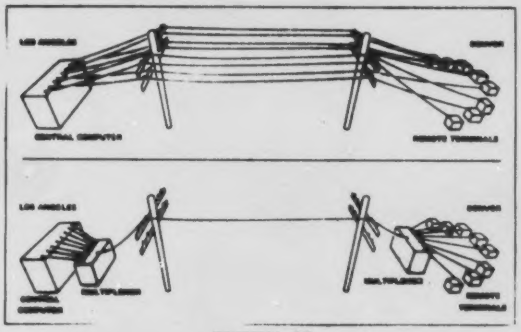


FIGURE 33

Some may be wondering how to reduce line cost by servicing more than one terminal on a single telephone line. Obviously, the answer is to take all line terminals in a common location and funnel them into the same phone line to the CPU, but how?

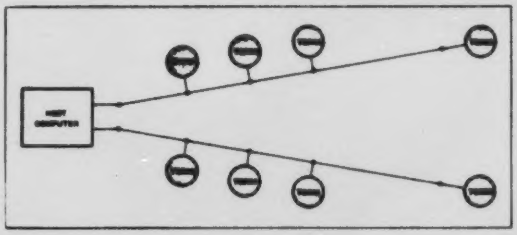


FIGURE 34

Polled Multi Drop would be one way - but this requires that the terminals be able to recognize an address and the computer port must be able to poll the terminals. In most minicomputer based systems, this is not practical.

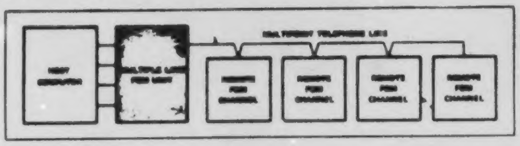


FIGURE 35

Multipoint is different - each port is associated with only one terminal via a frequency division multiplexed (FDM) modem that takes a single portion of the telephone handwith.

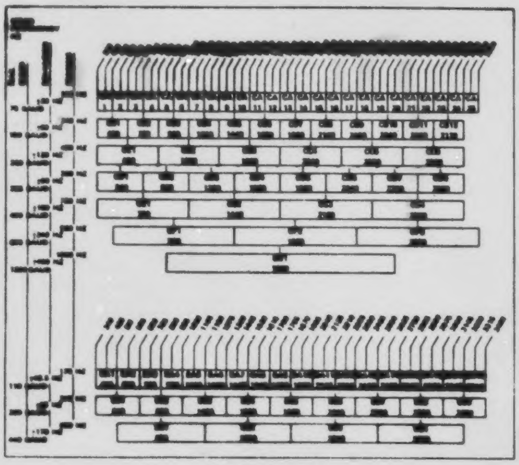


FIGURE 36

The only problem with the FDM approach is that any individual terminal is restricted to 300 bps at 6 terminals per line--or one 1200 bps and two 300 bps terminals per line. Maximum throughput with FDM is 1800 bps per telephone circuit. The major advantage is that one terminal can be located in Ventura, another in Santa Barbara, and another in San Luis Obispo with a low cost ($500) modem at each terminal location. (The CPU site would be about $1,200).

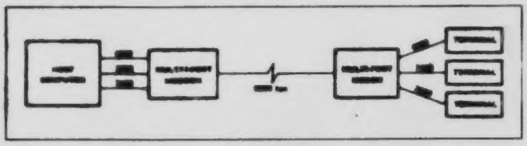


FIGURE 37

If strictly synchronous multiple terminals from a single location are of concern, then a multi-port modem may fit the requirement. Each synchronous stream is merged into the high speed stream over the phone line and split out at the other end. This technique is used with 4800 and 9600 bps modems in the $4,000-$6,000 range.

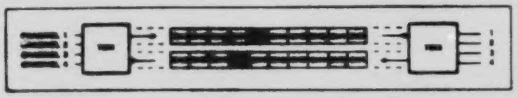


FIGURE 38

Time division multiplexers (TDM) are like rotary switches. A TDM looks at Channel A, B, C, D, etc. in sequence and assigns the channel to a time slot in the high speed composite data stream without regard to whether data was present or not. TDM is efficient only if the total utilization of all individual channels are high. If channel utilization is low, a lot of "non-data" is sent.

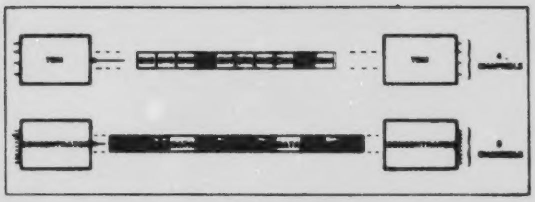


FIGURE 39

Statistically - hence the term statistical multiplexer, most channels will not be used all the time. If a TDM can ignore channels that have no data to transmit, then a busy data channel can be put into the lazy channel time slot. Add to this retransmission-on-error, and a very powerful box develops. Up until last year, statistical TDM's cost over $10,000. Today, $1,150! Savings in the TDM is only part of the gain. Consider that four 1200 bps terminals can be run thru one 2400 bps modem ($625) because of the increased efficiency of a statistical multiplexer. With a conventional TDM, the modem speed would have to be the aggregate of channel rates 4 x 1200 = 4800 bps - $3000 per modem.

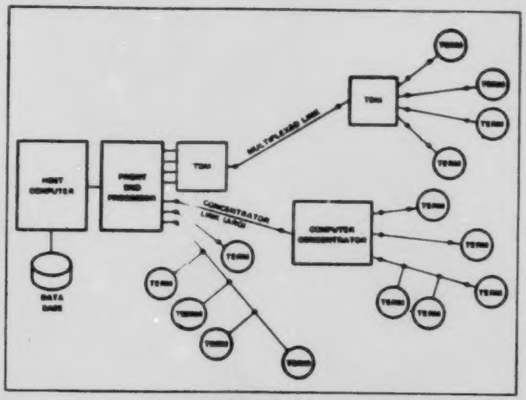


FIGURE 40

As systems grow, combinations of all the modems and multiplexers discussed may be used to transmit data to the locations required to service. This example is not at all unreal for a large computer complex.

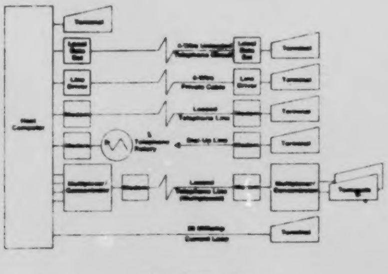


FIGURE 41

This is more likely what will happen to the mini-computer based, in-house time shared system. The only disadvantage is that as more of those cost savings, dedicated lines are added, ports on the CPU are committed to terminals that may not be active.

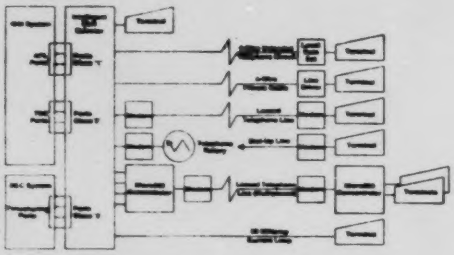


FIGURE 42

However, when that happens, we can provide a Port Contention switch to route any terminal to any comptabile computer.

CONCLUSION

Growing up with the electronics industry over the past 20 years, I take particular delight in seeing what is being done with LSI and micro-computer technology.

Technically complex solutions that were prohibitively expensive two years ago are now being implemented in applications by non-technical users.

I hope this presentation sparks new ideas to implement and possibly generate new applications in data communications.

TELLUSCOPE PLAN

- A submarine Cable System for observing the earth's interior -

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Nippon Electric Company Limited
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Abstract

This paper describes an idea of an earth's interior observation system which is called "Telluscope".
The Telluscope system consists of a long line submarine cable equipped with a large number of seismometers and other geophysical sensors which will be deployed on the deep sea floor over several thousands of kilometers.
This system enables to investigate the structure of the earth's interior, especially the detail structure of the mantle under the ocean which is one of the most important problems in the solid earth geophysics.
This paper also proposes a technical feasible study about the Telluscope plan in the Pacific Ocean.

1. INTRODUCTION

The purpose of this paper is to describe an idea of an earth's interior observation system which will be deployed on the deep sea floor over several thousands of kilometers. Let us call this new observation system, tentatively, "Telluscope".
Since the earth is called Tellus in Latin, we wish to call this system as Telluscope in a meaning of "an apparatus for viewing the interior of the earth".

In the hardware aspect, the Telluscope system is an observation system which consists of a long line submarine cable equipped with a large number of seismometers and other geophysical sensors. For example, a Telluscope systems would be deployed first from Japan to Minami-Torishima (Marcus Island) in the Northwestern Pacific Ocean basin and then it would be extended to Hawaii, crossing the Western Pacific, and finally it would be landed on the west coast of the North America, crossing the Eastern Pacific. The Telluscope system is a large scale observation system which would be deployed crossing the Ocean (see Fig. 4).

The purpose of Telluscope is to investigate the structure of the earth's interior, especially the detail structure of the mantle under the ocean.
The problem to elucide the detail structure of the mantle under the ocean has been a very fundamental one in the solid earth geophysics and now it is one of the most important problems with which the solid earth geophysics is confronted. Because it is related to the verification of plate tectonics, it is indispensable for establishing the image of the Nature about the earth which we have at present.

The plate tectonics is regarded as a revolutionary hypothesis in the recent earth science which deals with such global tectonic movements as to create the sea, to split the continent. It has changed the former scinario about the earth's history in various ways during the past decade. The stage of the play of plate tectonics is upon the ocean floor. The major target of research is the tectonic movement of the crust and mantle which underlies beneath the ocean. The study of the plate tectonics has led to the concept of the ocean-floor spreading and the revival of the hypothesis of continental drift.

About the truth in the Nature, it has been required to prove these hypothesis. Several international research projects has been organized at present in the fields of geology and geophysics. The International Phase of Ocean Drill (IPOD) is one of them. IPOD is to investigate the age of the ocean floor, that is to determine the date when the ocean floor was created, by drilling deep sea floor and sampling basement racks using special deep sea drilling ship called Gromar Challenger.

In order to establish the image of the Nature about the tectonic movement under the ocean, it is indispensable to obtain exact and reliable knowledges, i.e. observation data on the detail structures of the crust and mantle beneath the ocean floor.
The Telluscope will meet such requirements.

2. PRINCIPLE OF TELLUSCOPE

In the first place, a principle of how the internal structure of the earth can be clarified by the Telluscope is briefly described hereinafter. The data on the internal structure of the earth are given mainly from travel-time curves of seismic waves which propagate through the interior of the earth.

Now, suppose that an earthquake occurred on the surface of the earth. Seismic waves propagate in every direction from the source. A propagation path of the seismic wave which penetrates into the earth is bent and come back again to the surface as shown in Fig. 1 (A). This is because the seismic wave propagation velocity increases with depth.

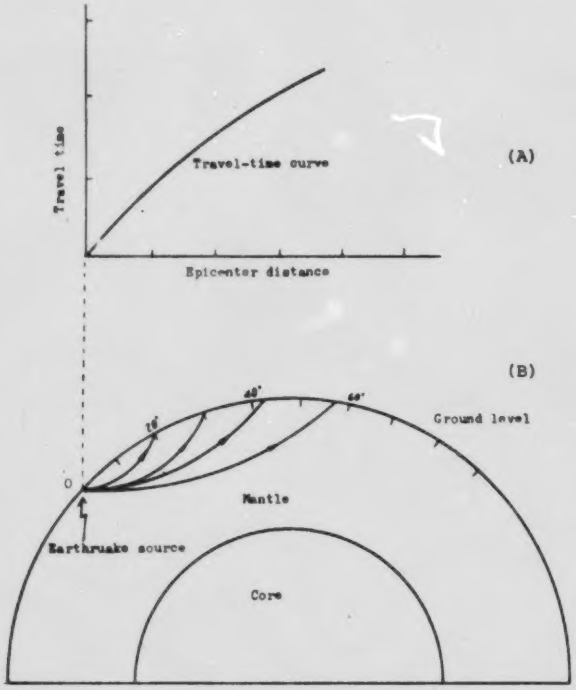


FIG. 1 PROPAGATION PATHS AND TRAVEL-TIME CURVE OF SEISMIC WAVE

A typical travel-time curve will be as shown in Fig. 1 (B). The shape of this travel-time curve is determined by the seismic wave velocity distribution in the earth's interior. Therefore, if a travel-time curve is observed in detail, the seismic wave velocity distribution is determined inversely from it.

A travel-time curve has several features. For example, (1) the deeper a seismic wave penetrates into the earth's interior, the farther on the earth surface from the earthquake source a seismic wave appears, and (2) an apparent velocity (horizontally propagation velocity along the earth surface) of a seismic wave at a certain distance is equal to the velocity at the deepest penetration depth of the path of the seismic wave, and so on (Gutenberg, 1959).

Therefore, in order to find a velocity distribution in a deeper part, it is necessary to observe a travel-time curve up to a sufficient distance. In addition to this, in order to obtain high resolution of velocity distribution, it is necessary to have many observation points with high density. The Telluscope is to realizes such high-density arrangement of sensors in a long-distance observation line, by taking the advantage of a favorable condition of the ocean floor.

Fig. 2 shows an example of seismic wave velocity distributions in the crust and mantle under the west of the North America, and Fig. 3 shows propagation paths of seismic waves in the mantle associated with the velocity distribution shown in Fig. 2. Under the lithosphere, there is a region called "low-velocity layer", wherein a seismic wave velocity is low, and in the further deeper region seismic wave velocity increases with depth.

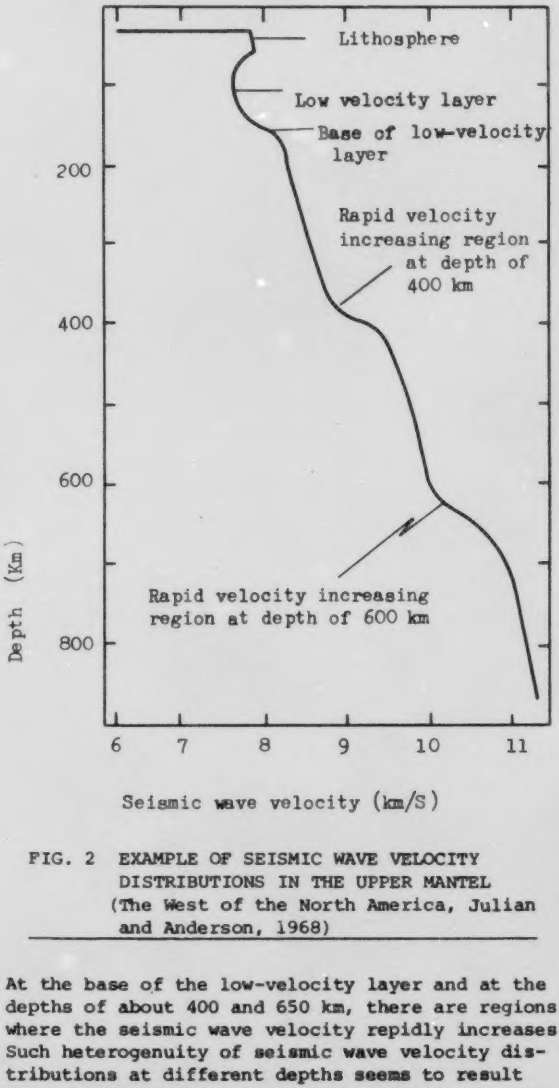
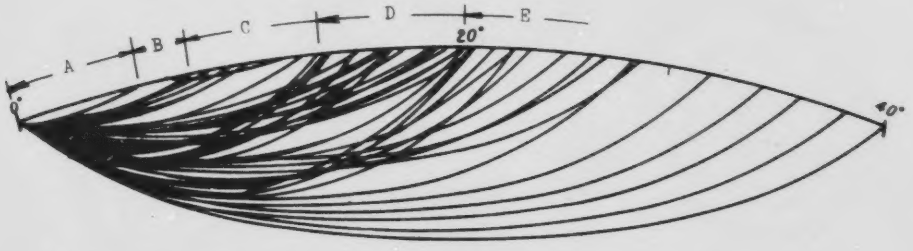


FIG. 2 EXAMPLE OF SEISMIC WAVE VELOCITY DISTRIBUTIONS IN THE UPPER MANTEL (The West of the North America, Julian and Anderson, 1968)

At the base of the low-velocity layer and at the depths of about 400 and 650 km, there are regions where the seismic wave velocity repidly increases. Such heterogenuity of seismic wave velocity distributions at different depths seems to result from the fact that types and conditions of rocks, which constitute the upper mantle, vary stepwise with the temperature and pressure distribution in the earth. Because of such complex velocity variations, travel-time curves show various complex features.

As can be seen from Fig. 3, when a seismic wave meets the low-velocity layer, it generates so-called "shadow" zone, where the seismic waves are not observed. A range of such "shadow" zone is determined by the depth and thickness of a low-velocity layer, velocity gradient, etc., and this is very important observation data for finding low-velocity layer. A seismic wave, which has been bent from the base of the low-velocity layer, appears in the vicinity of epicenter distance of about 8 degrees (approx. 900 km; 1 degree = 111 km). On the other hand, seismic waves, which have been bent from the rapid velocity increasing regions at the depths of about 400 and 650 km, appear in the vicinity of epicenter distances of about 15 and 20 degrees respectively. Their amplitudes are generally large. Consequently, a travel-time curve at an epicenter distance of up to 30 degrees reveals seismic wave velocity distribution at depth of up to about 700 km. Therefore, the seismic wave velocity distribution in the upper mantle at depth of up to 700 km can be clarified by observing travel-time curves at epicenter distances of up to 30 degrees.



A : Region of seismic waves travelling through lithosphere

B : "Shadow" zone relative to the low-velocity layer

C : Region of seismic waves reflected from the base of low-velocity layer

D : Region of seismic waves reflected from the rapid velocity increasing region at depth of about 400 km

E : Region of seismic waves reflected from the rapid velocity increasing region at depth of about 650 km

FIG. 3 SEISMIC WAVE PROPAGATION PATHS CORRESPONDING TO VELOCITY DISTRIBUTION SHOWN IN FIG. 2.
(Julian and Anderson, 1968)

Since there is almost no low-velocity layer under the old continents such as West Russia and Scandinavia, which are called shield, a seismic wave which propagates through the lithosphere is observed at a long distance, up to 15 degrees or more in epicenter distance. On the other hand, a low-velocity layer developes thickly under the recent orogenic belt as in the West of North America, and a "shadow" zone appears at an epicenter distance of about 5 to 6 degrees.

It is a big problem at present to clarify how the low-velocity layer developes under the ocean floor. This will be solved by observing a travel-time curve almost continuously over an epicenter distance of about 30 degrees.

3. A PLAN OF TELLUSCOPE

Since it cost much to construct the large scale Telluscope which crosses the Pacific Ocean, and since it is difficult to realize it abruptly, it will be practical to begin with a simplest but useful Telluscope. The purpose of this system is to investigate the upper mantle structure under the ocean by observing earthquakes which occur along the circum-Pacific earthquake zone.

Locations where the Telluscope is to be deployed are selected as shown in Fig. 4. An observation cable, to which sensors such as seismometers and hydrophones are attached, starts from Japan to the southeast, toward Minami-Torishima (Marcus Island), crossing the Japan trench, upon the North-western Pacific Ocean basin up to the point near 30° N and 148° E.

At the front end of Telluscope, about ten (10) sensor packages are set in array in such a manner as to cover a circular area of about 100 nautical miles in diameter. The purpose of this circular arraly stations is to observe an apparent propagation velocity of a seismic wave at high accuracy. To the long-lined Telluscope cable from Japan to the front end, about ten (10) sensor packages will be attached at about every 40 nautical miles appart. This linear array is to observe the long range travel-time curves. The total length of the observation cable will be about 2000 km including the array stations at the front end.

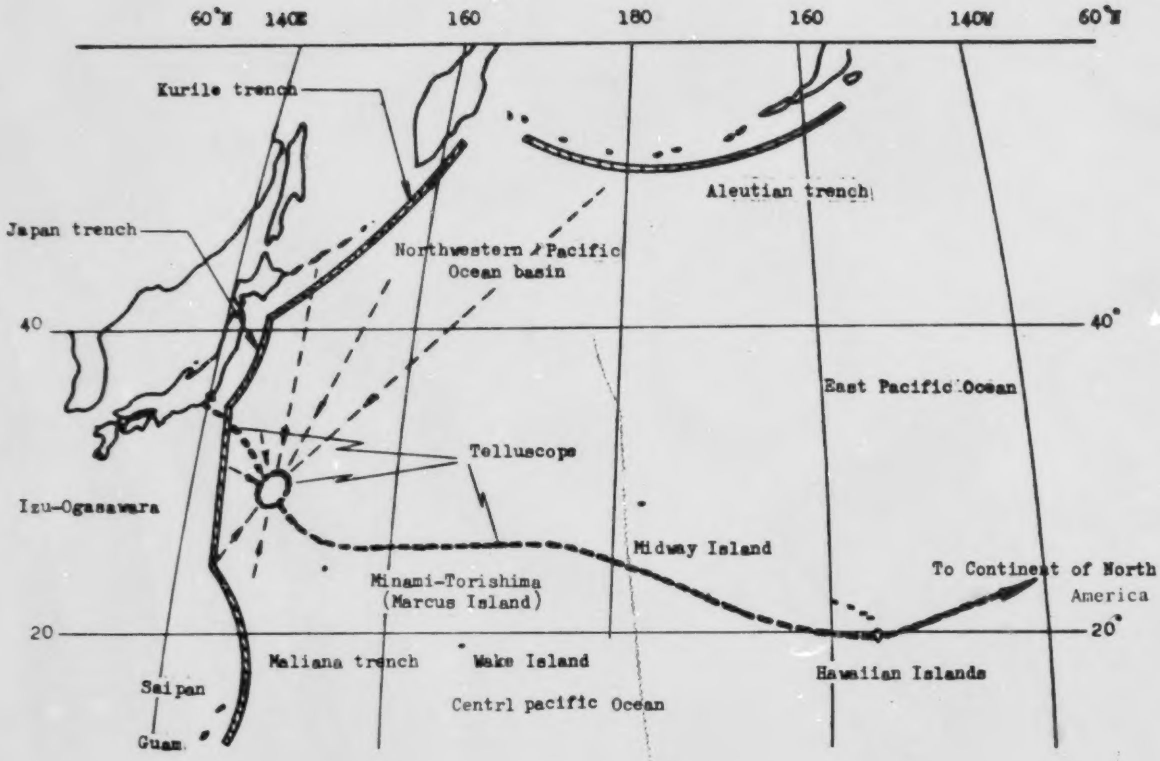

60°N
140E
160
180
160
140W
60°N
Kurile trench
Japan trench
Northwestern Pacific Ocean basin
Aleutian trench
40
40°
East Pacific Ocean
Telluscope
Izu-Ogasawara
Midway Island
Minami-Torishima (Marcus Island)
To Continent of North America
20
20°
Maliana trench
Wake Island
Hawaiian Islands
Saipan
Guam
Centrl pacific Ocean

FIG. 4 TELLUSCOPE ARRANGEMENT

The sensors consist of seismometers for measuring three components (one vertical and two horizontal), hydrophones, pressure gauges, thermometers, etc. The channel capacity which is required for data transmission is estimated as 120 channels; at 6 channels/sensor package, and 6 channels x 20 (sensor packages) = 120 channels.

Table 1. shows the electric signal converted from each sensor. The signals are converted primarily by frequency modulation (FM), and then, allocated in the frequency band on the transmission line (FDM). The frequency allocation on the transmission line is divided into low band and high band as shown in Figure 6. The low band transmits the sensor's signal from the sea bottom to the shore station and high band transmits the command signal from the shore station to the sensors.

The low band is preferred for transmission of sensor's signal, because of its good noise performance. The seismograph signal is allocated in the lowest band for this reason.

The modulation system in this case is FM-FDM. But there is another system called PCM. PCM system technology at present is inferior to the FM-FDM system, because of its poor reliability. This results from a large number of components (more than ten times the FM-FDM system) and a large power consumption. The proposed FM-FDM system in this paper uses the same technology as the modern telecommunication submarine cable system and its mean time between failure (MTBF) is 20 years.

TABLE 1. ELECTRIC SIGNAL FROM THE SENSORS

Kinds of sensor	Electric signal
1) Pressure gauge sensor signal	sensor output ; 8∿23 kH Analog signal frequency sensitivity ; 0.2 Hz/10 cm
2) Thermometer sensor signal	sensor output ; 100∿300 kHz band frequency sensitivity ; 10∿20 ppm/°C
3) Seismograph sensor signal	frequency band ; 0.03∿10 Hz one vertical, two horizontal
4) Hydrophone	frequency band ; 10∿300 Hz
5) Order wire	voice telephone, using in a time of laying. FDM, double modulation.
6) Command signal	from shore station to each sensor gimbal posture control and output level correction.

FIG. 5 TELLUSCOPE CABLE ROUTE PLAN

B6-26

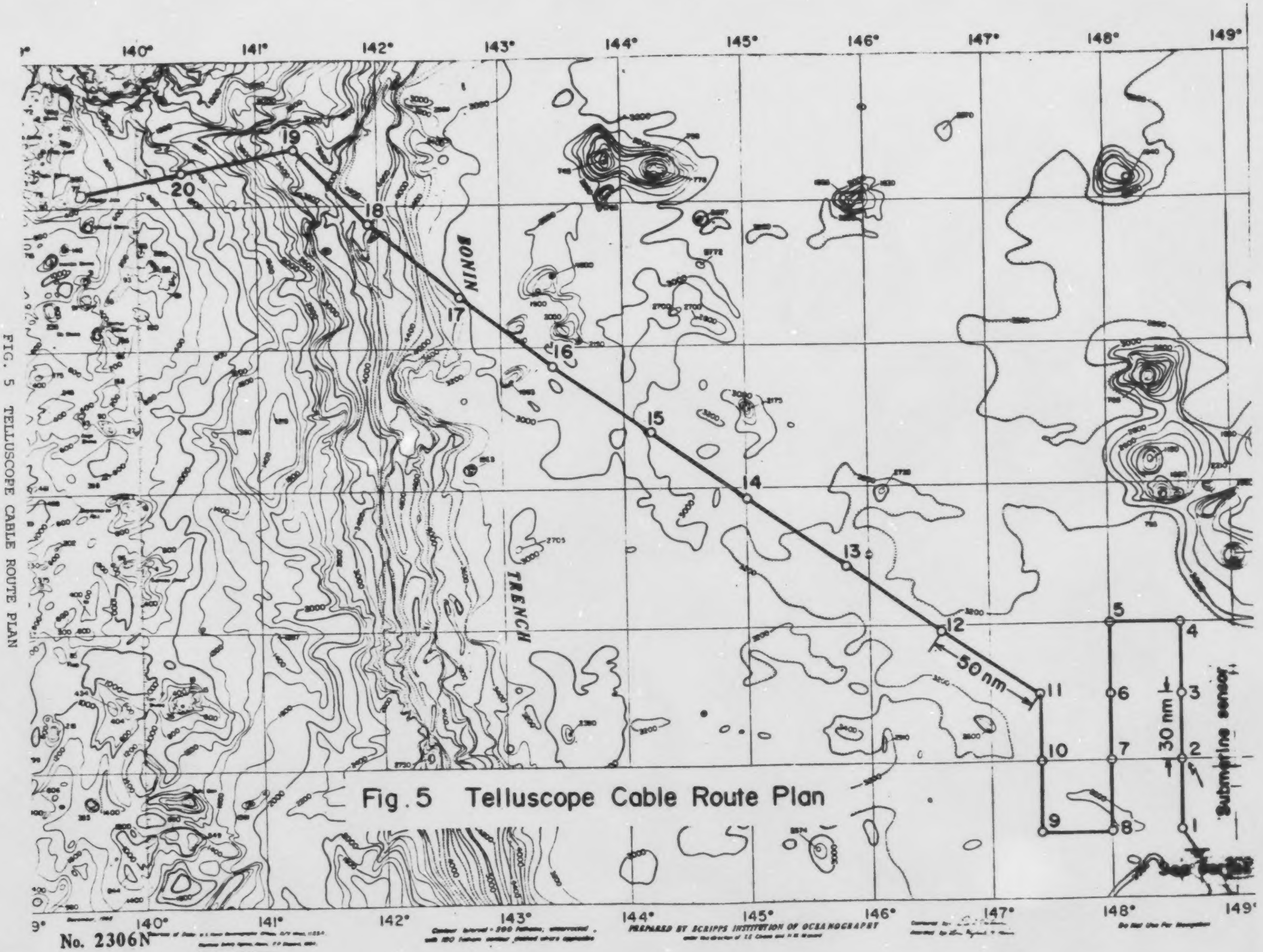

140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
BONIN
TRENCH
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
50 nm
30 nm
Submarine sensor
PREPARED BY SCRIPPS INSTITUTION OF OCEANOGRAPHY
No. 2306N

Fig. 5 Telluscope Cable Route Plan

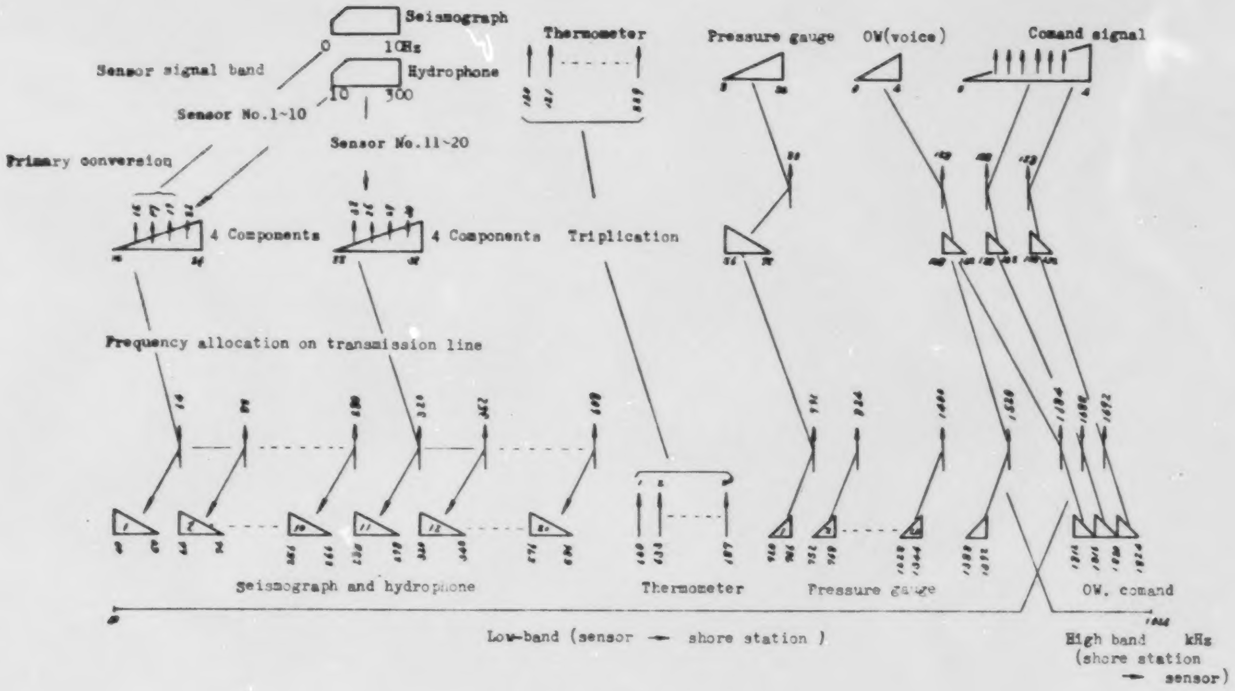

Seismograph
0
10Hz
Hydrophone
10
300
Sensor signal band
Sensor No.1~10
Sensor No.11~20
Thermometer
Pressure gauge
OW(voice)
Comand signal
Primary conversion
4 Components
4 Components
Triplication
Frequency allocation on transmission line
Seismograph and hydrophone
Thermometer
Pressure gauge
OW, comand
Low-band (sensor → shore station)
High band kHz
(shore station
→ sensor)

FIG. 6 FREQUENCY ALLOCATION

The submarine repeaters will be inserted every 25 km in a transmission line to keep the signal to noise ratio within a satisfactory level. For a submarine cable, 1.0" light weight coaxial cable is used. The quality and performance of this cable has been tested and proven. Figure 5 shows the Telluscope cable route plan which we are contemplating. According to this plan, the cable length is 2000 km, number of repeaters is 60, number of sensor stations is 20, Maximum sea depth is 8300 m.

Electric power is fed from the shore station to all repeaters and sensor stations. This power feeding system is DC constant current system which terminates a sea earth at the end of cable in the ocean, and a land earth at the shore station. The necessary voltage for the total system is about 2700 volt, and DC current is 150 mA.

If earthquakes occurring along the Izu-Maliana trench, Japan trench, Kurile trench and Aleutian trench are observed by the Telluscope mentioned above, travel-time curves at epicenter distances of up to about 30 degrees are obtained and, consequently, the upper mantle structure is determined up to a depth of down to 700 km. It is said that the age of the ocean floor of the Northwestern Pacific Ocean is the Cretaceous (about one hundred million to one hundred and thirty million years before present), and is considered as a typical old ocean floor. Consequently, the upper mantle structure under a fully evolved old ocean floor can be clarified by these earthquakes.

In addition, the Telluscope simultaneously observes other earthquakes which occur in other areas of the circum Pacific earthquake belt. Then, for instance, the earthquakes which occur along the Ryukyu trench and Phillipine trench will reveal the upper mantle structure under the Phillippine Sea, which were recently formed (about thirty million years before present).

The Telluscope also observes, moreover, earthquakes which occur along the deep seismic plane which is dipping downwards from the Izu-Maliana trench and Japan trench toward the deeper part of the island arc. The deep structure of the "subduction" of an oceanic lithosphere is clarified by these earthquakes. Especially it will clarify the role of a low-velocity layer (asthenosphere) in the process of the "subduction" of the oceanic lithosphere.

4. SIGNIFICANCE OF TELLUSCOPE

Let us consider the geophysical significance of the Telluscope with its background. The Telluscope is a research project which requires a huge amount of expense. Does the Telluscope really have sufficient scientific as well as social value worth paying such expense?

The image of Nature we have had about the internal structure of the earth in 1950's was that of an average earth. This image had been derived from regarding the whole of the earth as one structure, that is, an image of an earth consisting of several spherical shells such as crust, mantle and core. In 1960's, it was revealed that the internal structure of the earth vary with geological regions, and that the differences are closely related to the geological structure of the earth surface. In other words, we found a new image of Nature about the earth which has regionalities. The regions are classified into the three: shields, orogenic belts and oceanic regions. The most important element which characterize the differences amont these is the low-velocity layer.

It is known by seismic body wave study that the low-velocity layer is thick and prominent in an orogenic belt in the West of the North America, and that the low-velocity layer almost disappears in shield areas, such old continents as Canada, West Russia, and Scandinavia. It is also known from the seismic surface wave study that there are prominent low-velocity layers under the oceanic areas. The "low-velocity" layer is thought to represent such condition that a part of constituting rocks are partially melted by an extremely high temperature, and consequently elastic constants decrease, seismic wave velocity decreases, and rocks are apt to flow plastically. It is also thought that density of rocks decreases due to partial melting, and buoyancy is generated, and thus causes mantle convection and orogency. The existance of low-velocity layers is indispensable for the continental drift hypothesis or ocean-floor spreading concept to explain their dynamic mechanism.

In 1970's when the age of ocean floor has been clarified, we had an image of evolving earth. That is, the crust and mantle structures under the ocean evolve with age. The plate tectonics has an image that an oceanic crust is created at oceanic ridge, then spreads and drifts sidewards, and finally subducts under the continent from the oceanic trench.

As regards the evolution of an oceanic crust, it has been observed that a seismic wave velocity in the Mohorovicic discontinuity is higher in older layer, the water depth of the ocean floor is larger in older age, the ocean crust thicken rapidly in the first thirty million years, and so on. It has been explained that these phenomena might be resulted from the fact that a high-temperature crust and mantle which was formed at the oceanic ridge cool down to lower temperatures as they move far off from the ridge. As for an oceanic lithosphere, it was known from the seismic surface waves study that an oceanic lithosphere increases its thickness with ages, and the seismic wave velocity also increases with age. These phenomena has been explained by the temperature change and its associated phase change of the constituting rocks. On the other hand with progress of seismic body wave study, it has been known that the evolution processes in the upper mantle is not so simple as derived from the surface wave studies.

It was found in the Gulf of Mexico that a low-velocity layer, which is prominent in the oceanic area, is extremely poor there, and, instead, there is a high-velocity-layer in the lower lithosphere. It is very similar to that of a stable continent. A similar structure is reported in the Northwest Pacific, eastern off Izu Islands. On the other hand, it was found by long line seismic explosion experiments conducted in the Maliana basin that thick low-velocity layer develops there. This result in the Maliana basin is in good agreement with a model obtained from surface waves study. However, the oceanic floor of the Gulf of Mexico, Northwestern Pacific Ocean and Maliana basin are all of old age, more than one hundred million years before present. This means that different upper mantle structures were observed for the similar age of ocean floor.

If one apply an evolution model derived from surface wave study to the Maliana basin, it leads to a conclusion that the Maliana basin has a structure of younger age. This conclusion raises up a question that a low-velocity layer which develops under the Maliana basin might be related to the formation of the seamount group in the Central Pacific Ocean, Micronesia and Polynesia islands. In other words, the presence of a low-velocity layer under old ocean floor might be related to the recent submarine volcanic activities - mid-plate volcanism.

As regards the evolution of the upper mantle structure under the ocean bottom, Telluscope will provide definite data. Telluscope to be developed in the Northwestern Pacific Ocean on the east of Ogasawara Islands will definitely determine the upper mantle structure under the old ocean floor about one hundred million years old. Telluscope to be developed in the East Pacific Ocean between Hawaii and the North America will determine the structure of younger age, about ten million to to seventy million years.

Telluscope will provide important observation data not only for the problem of low-velocity layers under the ocean, but also for problems of the larger scale internal structure of the earth. There is a problem that how deep the regional difference between the ocean and the continent extends into the earth's interior. At the depths of about 400 and 650 km, there are regions where a seismic wave veclocity rapidly increases with depth. It has been speculated that the regional difference between the ocean and the continent might extends into these regions.

Telluscopes described in the foregoing sections are capable to detect the structures of these rapid velocity increasing regions. On the other hand, the structure of rapid velocity increasing regions under the continents has been clarified in detail by the large apperture seismic array station networks deployed in the continents for detecting underground unclear test.

The regional difference between the ocean and the continent will be clarified by comparing the structure of rapid velocity increasing region under the ocean with that under the continent. There is another speculation such that the difference between the ocean and the continent might extends as deep as to the mantle-core boundary. In order to detect such possibility, we have to observe the seismic reflection waves from the mantle-core boundary. The Telluscope will also provides valuable data for such comparison.

For considering the history of the ocean and continent, it is indispensable to know how deep the difference between the oceanic and continental structures extends. When the structure in the deep earth's interior is clarified by Telluscope, it will give us a positive key for depicting the image of dynamics about the earth's interior. It is a long time since Van Bemmelen proposed a geodynamic model which involve the whole mantle region. The observational data to test his model will be provided by Telluscope.

5. CONCLUSION

A prototype of Telluscope is a large apparture seismic array developed for unclear test detection and the submarine cable earthquake observation system of Japan Meteorological Agency which was built for earthquake prediction. LASA in Montana, USA, and NORSA in Norway in Scandinavian Peninsula are well known large apparture seismic arrays. In either system, 100 to 200 seismographs are arrayed in a nearly circular area of which diameter being about 100 to 200 km.

Detail upper mantle structures beneath the Russian platform, Scandinavian Peninsula and the central part of the North America have been clarified by these array stations. The Telluscope is a combination of two arrays, the one is an areal array like LASA and NORSA and form its front end, and the other is a linear array which form a long-distance observation line. By using a submarine cable as an observation tool, such an array station can be realized. It enables us, a high-quality transmission of a large quantity of data and centralized data recording. Techniques of the submarine cable earthquake observation system has been completed by the Japan Meteorological Agency in the summer of 1978 off the coast of Omaezaki. This experience will be extensively utilized for Telluscope. We will have several new techniques to be developed. How to cross the deep Japan trench which is as deep as 8,000 m, how many channels can be transmit crossing the ocean, how can we construct reliable long-period seismograph and etc. From the past experiences, the prospects of such new techniques are promising. In addition, if the development of the oceanographic sensors such as bottomcurrent meter, velocity meter are in time, trans-ocean oceanographic observation characteristics can be added to Telluscope.

Telluscope is based on a purely scientific idea of viewing the earth's interior, and is a tool for performing such basic research. One may ask for the social significance of such basic research. Telluscope may not result in today's profit. But we, man on the earth, are now sending men to the moon, and bringing back rock samples to the earth, and getting close-ups of the terra of the Mars and the face of the Venus and Jupiter. Though it is disappointing to see that the old images of the canal of Mars, man of Mars, which have been familiar to us since our childhood, are falling down one after another, we do see there that indisputable observation data strictly request us to change out old views. It will be important to obtain exact and reliable knowledges one by one about the earth where we, people must live. Even though the pure scientific knowledge about the earth does not bring us any realistic profit, isn't it nourishing a source of our social activities.

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TELE-CYBERNETICS: TODAY'S CHALLENGE

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Abstract

"Tele-cybernetics" is defined as "political science" in our Age of Telecommunications", as etymologically derived from Plato and Ampère. The paper relates our rather unwary arrival (into the Age) to C. West Churchman's quest for the 'hidden leadership' of America—of the Western world. Correctives, derived from the historical perspective, are tabulated.

1. INTRODUCTION

It is a well-known fact that the Greeks endeavored to study in a rational, systematic, way the many facets of the art of governing. Plato in particular used the term "cybernetics" in several of his dialogues (9) illustrating the cybernetic process with analogies taken from the piloting of a ship [The Republic, I] or the controlling of horse-driven chariots.

It is therefore not surprising that Ampère, as item 83 in his *Classification des Connaissances Humaines* (1834) (1), chose to re-introduce the term "cybernétique" to refer to "political science," defining it as "l'art même de gouverner et de choisir dans chaque cas et ce qu'on peut et ce qu'on doit faire, *science des hommes d'Etat* (italics added)" (p. 258).

In 1948 appeared N. Wiener's book *Cybernetics: or Control and Communication in the Animal and the Machine* (20). In that book, the author categorically asserted that "the term 'cybernetics' does not date further back than the summer of 1947" (p. 12) and, regrettably, completely disregarded or ignored earlier users of the term. This oversight was repeated in Wiener's book, *Human Use of Human Beings: Cybernetics and Society* (1951) (21); then, in 1954, Wiener added an introductory chapter to a paperback edition of that work, admitting, quite in passing, the "possible" existence of a few predecessors: "Incidentally, I [Wiener] found later that the word had already been used by Ampère with reference to political science, and had been introduced in another context by a Polish scientist, both users dating from the earlier part of the 19th century."

Reason can be shown historically to be founded on the proper control of human communications, particularly written communications, whether prepared by hand and transmitted via the post or published by press and disseminated to individuals and to archives.

The essence of any political system is indeed social communication and its control. In this context, "tele-cybernetics" is of paramount concern to cyberneticists as the political implications of telecommunications without "tele-control" become evident.

It is increasingly obvious that Reason did not prevail in the German democracy in this century. Payne (15, p. 569), e.g., notes that "Hitler's rise to power coincided with the invention of the cheap mass-produced radio" without the advantages of which "he would never have been so successful in establishing his totalitarian regime." Has democratic America, with its mass-produced television, waited too long to heed the lesson of the *National Socialists*?

The advancement of civilisation, via its accumulation of intellectual understanding (11), involves a fundamental cybernetic process (as exemplified in Figure 1):

(a) an archive of recorded observations [EXTANT KNOWLEDGE]: artifacts (housed in museums) and written works (stored in libraries);

(b) a comparison of the facets of existing knowledge leading to an INSIGHT;

(c) a formulation of sets of principles, in the form of hypotheses (physical or written models) [POSTULATED HYPOTHESIS];

(d) the logical and grammatical testing [MODEL SCRUTINY] and the challenging [CONFIRMATION] of (c) and (b), respectively, so as to verify and validate any postulated hypothesis; and,

(e) the acceptance of the scrutinised and confirmed hypothesis as a legitimate contribution to human knowledge [KNOWLEDGE CONTRIBUTION].

The two control aspects (i.e., (d) above) necessary to Reason can be assessed by examining briefly the types of various models available to Man in his effort to formulate and communicate his thoughts, creations, and innovations to others. An examination of Reason's continuing requirement for controls in our Age of Telecommunications will then follow.

2. MODELS: VEHICLES FOR COMMUNICATION

A model, according to Rivett (17, p. 1), is "first of all a convenient way of representing the total experience which we possess, of then deducing from that experience whether we are in the presence of pattern and law, and, if so, of showing how such patterns and laws can be used to predict the future." Man's modelling formats have evolved historically in a quite constructive fashion:
(1) mental models; (2) physical models; and,
(3) literal models.

2.1 MENTAL MODELS

Sir Francis Bacon's (2, p. 272) first aphorism (in *Magna Instauratio*, 1620) points to the fundamental problem of man's limitations in "knowing" the world about him without the help of tools. Man's dependence on sensuous observation, perhaps better termed "experience," is characteristic of animals generally. Experience can be considered as each man's (or animal's) collection of neurally recorded models regarding his life. However, as opposed to other animals, Man has broadened the field of his immediate experience with the help of tools and, since he is a "tool-making animal," an additional type of model becomes possible: physical models.

2.2 PHYSICAL MODELS

The cave drawings of primitive man were apparently the attempts to record, for the benefits of both others and other generations the experience (mental models) of their artists. More recently, the sculptures of Michelangelo, the anatomical drawings of da Vinci, as well as orreries typify physical models made available as *communications* for the examination and enlightenment of others.

Yet, physical models cannot provide Man with the richness of expression made possible by language. As Sarton (19, Vol. 1, p. 4) has aptly remarked, Man "can go very far without writing, but not without language. Language is the bedrock upon which any culture is built."

As opposed to the languages of other animals, human language permits the construction of extremely complex and abstract models. Even more significantly, Young (22, p. 267) has noted the fundamental characteristic of Man: "by means of language and tools he constructs models of the world outside his own brain and outside his own genetic system." Indeed, the codifying of thought into strings of connected phonetic segments that are understood as words is apparently characteristic of Man alone [cf. (14) and (18)]. With the help of grammar, the building of literal models became possible.

2.3 LITERAL MODELS

It would appear that, with the evolution of grammatically-controlled language, a parallel evolution took place: models, based on language, became more and more complex in order to provide Man with more complete and accurate explanations of the world. The evolution of language has provided three fundamental types: (1) natural languages; (2) mathematics; and, (3) computer-directed languages.

2.3.1 *Models in natural language* - We have no record of the earliest model produced in natural language by primitive man, since, at the very early stages of civilisation, writing was deemed neither essential nor necessary. The Incas of Peru, whose civilisation was indeed complex and advanced, had an elaborate language but no system of writing (19, Vol. 1, p. 4). The earliest writings that have come down to us are those of Egypt's Old Kingdom (c. 3400-c. 2475 B.C.) written in hieroglyphics: a set of conventionalised, standardised pictograms (images) which we may regard as a transition language between that of physical models (paintings) and that of literal models based on a purely grammatical mode of expression. It is interesting to note that one of the earliest available literal models is a mathematical treatise (The Rhind papyrus, now in London, written c. 2000-1788 B.C.), one whose initial sentence promises the "rules for enquiring into Nature, and for knowing all that exists [every] mystery, ... every secret." (19, Vol. 1, p. 37).

Nonetheless, because of the polysemous and ambiguous nature of words, it becomes necessary for any natural language to be structured according to a set of rules: a grammar. We could thus view grammar as a conventional set of formulae (or paradigms), whose property is definitude (precision) and whose aim is internal consistency in the modes of expression. Thus, strict adherence to these rules largely eliminates confusion and permits a freedom of expression quite analogous to the freedom of movement and social interaction which a legal (political) system offers to the individual living in a social structure.

Included in this category of literal models are the explanations of natural phenomena in anthropomorphic forms (myths) (6 and 5), philosophical treatises (e.g., those of Plato), or scientific descriptions (Darwin's theory of evolution). However more rigorous and demanding in precision are models expressed in the language of mathematics.

2.3.2 *Mathematical models* - based more strictly in logic, the grammar of mathematics permits a more precise testing of the inner consistency and accuracy of these models. The invaluable advantage of such models is their ability to describe natural phenomena in extremely abstract terms: for example, Newton's Laws.

Closely linked to these models are the recent and quite contemporary developments in the preparation of models based on computer-directed languages.

2.3.3 *Simulation models* - computer-directed (second-person) languages can be employed to author models of aspects of Nature and, in particular, natural systems. The fundamental favorable characteristic of these simulation models is their capability to incorporate an immense amount of detail, thereby making them ideally suited for the scientific description of the natural complexities termed *systems*.

The fundamental question concerning any one of the three categories of literal models and their diffusion and acceptance is *not* whether any one of them is the *only* correct type, but rather whether the results of any particular model could survive the tests of objective scrutinisation and confirmation. Herein lies the most important aspect of the cybernetic process: objective *control*, so important indeed that even Wiener (20) placed it ahead of "communication" in his definition of "cybernetics."

3. CONTROL MECHANISMS IN THE ACCEPTANCE OF MODELS

The cybernetic process by which Man's models are verified and validated is depicted in Figure 1 [See also (12)]. Before a model can be considered a KNOWLEDGE CONTRIBUTION, its credibility must first be established by means of verification [MODEL SCRUTINY]; that is by the elimination, in the literal model [POSTULATED HYPOTHESIS], of any linguistic ambiguity or obscurity. (The computer scientist's word for rectifying computer-directed sentences is "debugging".) At this stage, reformulation of the postulated hypothesis may become necessary so that confusion is eliminated, thereby establishing the internal consistency of the model. The second step of accomplishing a model's credibility is its validation [CONFIRMATION]; that is, one must establish whether the verified model conforms to observable (observed) reality. Should the model fail such a test, a return for a further examination [INSIGHT] of Nature must be undertaken. However, it may sometimes occur that the source of difficulty is a somehow previously undetected grammatical error, simply necessitating additional "linguistic" corrections by means of a return to the model itself [POSTULATED HYPOTHESIS].

An Example: Perhaps one of the most interesting examples of the cybernetic process of Science through history is the discovery of electromagnetic waves in space, making possible the invention of wireless telegraphy.

According to Aristotle (*De Anima* (405 A), which one would consider as a natural-language model; supra 2.3.1), Thales de Miletos (born c. 624 - died 548? B.C.) claimed that the magnet (loadstone) has a soul because it moves particles of iron. Thales also noted that rubbed amber would attract lightweight bodies such as feathers. This anthropomorphic explanation of two natural phenomena was accepted as a satisfactory explication.

Indeed, the validity of such mythical thinking as an *initial* mode of reasoned explanation is gaining increasing recognition (5 and 6). Myths, just as scientific hypotheses, are models of the world: models communicated to a community so that their validity be questioned and investigated. This has led Popper (16, p. 84) to assert that science "is a step at which our explanatory myths become open to conscious and consistent criticism and at which we are challenged to invent new myths."

The phenomenon of magnetism was finally subjected to critical study by William Gilbert (1544-1603), Court Physician to Queen Elizabeth I. His research led him to distinguish between the attracting powers of loadstone and that of rubbed amber, the latter of which he named "electric," taken from the Greek word, "ELECTRON," for "amber" (7, p. 306). In this manner, Thales's myth on magnetism was set aside by Gilbert's more scientific model on electricity.

It is interesting to note, as a point aside, that Gilbert's contemporaries (in particular, Sir Francis Bacon) did not accept his hypothesis that gravity and the rotation of the earth could be explained analogically by merely invoking his principles of magnetism. To Bacon, such an hypothesis was unacceptable because, though the logic of Gilbert's model was virtually unassailable, *it was built strictly on an analogy rather than being supported by experimental methods and observable data* (2, p. xix).

In 1812 Hans Christian Oersted (1777-1851) contributed further to Gilbert's insight. He suspected that there was a connexion between electricity and magnetism. This hypothesis, purely based on belief, was published in his *Views on Chemical Laws* (1812). His discovery of electromagnetism occurred in 1820, when he proved, by demonstrating that a magnetic needle could be deviated by an electric current, that magnetism can be induced into a wire with an electrical current.

André-Marie Ampère (1775-1836), who had seen in 1820 a demonstration of Oersted's discovery, conducted additional research and was able to author a mathematical formula for the force between elements of current. This was published in 1827: *Sur la théorie mathématique des phénomènes électrodynamiques uniquement déduite de l'expérience*. Thus, with Ampère's formula, a written model of electric phenomena [POSTULATED HYPOTHESIS] was made available for the scrutiny of his contemporaries.

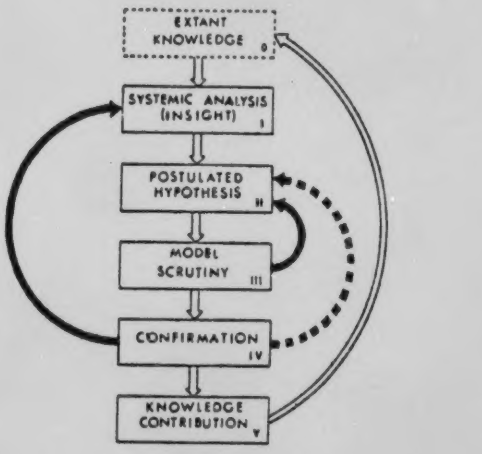

Figure 1. SCIENTIFIC METHOD.

Many of Ampère's contemporaries [particularly Joseph Henry (1797-1878)] studied the problem initiated by Oersted's work, yet Michael Faraday (1791-1867) noted the vibratory properties of induced magnetic currents and came forth with a more refined postulated hypothesis known today as field theory: namely, that the real energy of the magnet was in the space around it, the magnet itself acting as an object through which were concentrated the lines of magnetic force.

Most of Faraday's contemporaries rejected this idea [MODEL SCRUTINY] but James Clark Maxwell's work, which culminated in 1873 in his Treatise on Electricity and Magnetism, provided further reinforcement to Faraday's view [MODEL SCRUTINY, which led subsequently to a more refined POSTULATED HYPOTHESIS]. Maxwell (1831-1879) showed indeed that all known electric and magnetic phenomena could be interpreted in terms of stresses and motions of a material medium.

Ten years after Maxwell's death, the German physicist Heinrich Hertz (1857-1894) confirmed Maxwell's model. He was able to generate and detect electric magnetic waves at a distance from their source and demonstrated their existence in the manner proposed by Maxwell. He also showed that these waves have essentially the same properties as those of light. Wireless telegraphy was to be one of the most significant outcomes of this field of enquiry.

Indeed, one could note that what was simply a myth, an anthropomorphic explanation of Nature stored in the archives as a literal model (Aristotle's De Anima, for example), was made available for questioning and rectification. Subsequent research (and innovation), with the help of increasingly sophisticated research tools (instruments) and complex mathematical models, has allowed for the creation of today's omnipotent vehicle for massive human communication: television.

4. TELECYBERNETICS: CONTROL AND COMMUNICATION IN MODERN SOCIAL SYSTEMS

Just as Man's evolution of models has historically progressed because these communications have been subjected to the control of grammatical laws, so must the evolution of human communications itself be controlled to ensure that Reason prevails. In today's extremely rapid system of communication, the need for serious evaluation of widely disseminated material cannot be overemphasized. Yet, the historical record indicates that we may well have regressed in our efforts to provide the "public" with information. This historical evolution of human communication records three distinct stages: α. oral communications; β. written communications; and, γ. telecommunications.

4.1 THE 'DAWN' OF CIVILISATION: ORAL COMMUNICATIONS

Before the invention of printing, the only available means of massive communication was the spoken word. For messages to be transmitted over distances, messengers could be arranged in a relay fashion; yet, such a system of communication faced three dangers requiring control, since a message could be:

(1) lost prior to its destination because of a broken link in the communication chain;
(2) willfully altered by sabotage; or,
(3) accidentally contorted as it passed from one messenger to another.

4.2 THE 'DAY' OF REASON: WRITTEN COMMUNICATIONS

With the advent of writing, messages could be transmitted by the ancestors of the postal services: carrier pigeons, thus eliminating accidental contortions and a great deal of willful alteration. The invention of printing permitted the widespread dissemination of written communications, with two considerable advantages:

(1) The "message" could be preserved in a fashion more durable than either a neural recording (memory) or a rare manuscript; only fires, floods, or other natural disasters could threaten the loss of the message.

(2) The "message" could be stored by many for further examination and/or challenging and testing without considerable fear of willful alteration or accidental distortion; only by editing or misquoting could the message be distorted to serve the aims of propagandists, for example, though admitedly the polysemous and ambiguous nature of natural languages permits still a "play on words" or outright deceit.

Written communications, subjected to proper social controls, constitute the foundation of Reason. Ampère's definition of "cybernétique" as "political science" becomes interestingly quite the same as that of Wiener.

4.3. THE 'DUSK' OF CIVILISATION: TELE-COMMUNICATIONS

The invention of radio and television returns Man to emphasise oral communications. The obvious advantages of social telecommunications are speed and the elimination of geographical and temporal barriers to the diffusion of messages. Conceptually, the analogous controls (or the archival storage of written communications) could be exercised by the recording of telecommunications on tapes or films (for storage in secure repositories). Thus, the loss of messages and the willful or accidental distortion by erasures or splicings could be avoided.

Even if these measures of "tele-control" were to be employed, one must certainly enquire of their adequacy in view of the possibility that the willfully or carefully delayed timing of the release of information via social telecommunications media can play an important role in the actions of those who partake of the information. Furthermore, even though social telecommunications could be recorded and disseminated, the individual auditor will not likely seek to verify and validate their messages by means other than his own mental recording (his own recollection) of what had been said.

One might well reflect on the wisdom of Lewis

Carroll (3, p. 271), who noted that the mind seems to accept as truth whatever is three times presented to it orally:

> "What I tell you three times is true."

One could note as well Payne's observation (15, p. 569) that "even when he [Hitler] lied outrageously, and they knew that he was lying, the Germans preferred to believe his lies rather than face the consequences of truth." Telecommunications without "tele-control" is an historically proven "Challenge to Reason." Churchman (4, pp. 74-75), in a book of that title, describes vividly the current threat of an extant "'hidden leadership'" who act on "a desire to be leaders and controllers of public opinion.... And there is no guarantee that the hidden leadership itself is well informed."

Presumably this "hidden leadership" *may* be somewhat distinct from the titular leadership of the telecommunications media. Who or what group might constitute Chruchman's "hidden leadership" ? [Cf: Table I.]

5. CONCLUSION

On the positive side, the important tools of our Age of Telecommunications (computers, telephone, and television), when properly used, provide us the opportunity to understand better and to control both natural and societal systems. For example, the relatively recent development of simulation as the methodology for the scientist of systems provides a path for Reason to travel. Computerised models made possible Man's voyage to, and his exploration of, the Moon. Indeed, were it not for

TABLE I

An Historical Record
Addressing the "Hidden Leadership" of C. West Churchman's
CHALLENGE TO REASON

Record	Source
1. By taking advantage of the then newly developed and mass-produced telecommunications medium (radio), the *National* Socialists were able to mesmerise the German population, "coercing" them to adopt a single political viewpoint, eventually to commit atrocities.	Robert Payne, *The Life and Death of Adolf Hitler*, p. 569.
2. In pre-Nazi Europe, a particular politico-religious group was considered an "elusive" business people with a knack for operating internationally and were hated for taking advantage of their natural "international connexions."	Erik v. Kuehnelt-Leddin, *National Review*, 13 September 1974 , p. 1044.
3. An immense number of emigrants from Nazi Germany took refuge in New York City, the control center of the American telecommunications network and media, in immediate proximity of its largest scholarly institutions: libraries and museums.	
4. This class of immigrants was and *is* predominantly of one political inclination.	A. H. Halsey and M. A. Trow, *British Academics*, pp. 414-415
5. There exists a disproportionate percentage of university faculty of a particular religious upbringing in the United States, particularly among the "more prestigious" schools.	K. R. Hardy, *Science*, 9 August 1974, p. 503.
6. A few citizens have noted the existence of a "hidden leadership" behind the titular leadership of this nation's telecommunications industry.	C. West Churchman, *Challenge to Reason*, p. 74.
7. The historical acquisition of human knowledge, of Reason, is due to its cybernetics (i.e., via human *communications* and their *control*), as particularly exemplified by the academic procedure of reviewing and *correcting* publications, both before and after their appearance in the printed literature.	G. Arthur Mihram, *An Epistle to Dr. Benjamin Franklin*;*

*Have we, as Men of Reason, failed to heed the Lessons of History, to permit an irrational, dangerous, or vengeful application of uncontrolled telecommunications?

the "frenzied" simulations, computerised on Earth so as to determine the best course of action, astronauts James Lovell, Fred Haise, and John Swigert (Apollo 13) might never have returned safely to Earth (10, p. 63).

Our challenge and responsibility today is the reduction of erroneous (negative) decisions and the reinforcement of correct (positive) actions. To translate Laplace (8, Vol. 2, p. 23), the word "chance" is really "no more than the expression of our ignorance," and, in our efforts to better understand and control our environment, it behooves us to reduce as much as possible the "chances" of failure.

The history of the evolution of any field of human endeavour is the account of the success or failure of its models (physical or literal) to explain and predict natural phenomena. Whether one considers the philosophical problems of humanity, or the scientific and mathematical puzzles of the classical scientists, or the behavioural enigmas puzzling social scientists, the ultimate concern remains the same: the rigid adherence to a disciplining which ensures both the correct diffusion of insights and the reduction of their errors.

Museums and libraries have proved the essence of the control on Man's physical and literal models. In an Age of Telecommunications, an International Archives for the Scientist of Systems is in order (13). More importantly, one must ensure that the collective mental models, formed in neural recordings by the social tele-communications media, are subjected to a proper "tele-control." We require tele-cybernetics. [Cf. Table II].

17 September 1979

TABLE II

A PROPOSED AMENDMENT (ON TELE-COMMUNICATIONS)
TO THE CONSTITUTION OF THE UNITED STATES OF AMERICA

We, the people of the United States, desiring to continue to form a more perfect union, to establish justice, to ensure domestic tranquility, to provide for the common defence, to promote the general welfare, and to secure the blessings of liberty to ourselves and our posterity, do recognise both our arrival, from the Age of Written/Printed Language (1787), into our Age of Telecommunications and our awareness of the founding basis of truth[1] and of honesty[2] to the survival[3] of this Republic. We do therefore ordain and establish the following amendment empowering the Congress:

(A) To make all laws ensuring that person-to-person tele-communicative instruments[4] be self-policing[5,3] and/or be subjected to interception by and only by authorised officials whenever the likelihood of tele-communicative messages either pornographic or treasonous can be established;

(B) To enact legislation ensuring that: (1) the band-limited social tele-communicative media[6] are subjected to the demanding scrutiny[7] necessary to ensure that the irrefutable truth[1,3] is broadcast or, as required, corrected expeditiously; (2) the right of any accused to a fair, speedy, and public trial shall not be thwarted by the tele-communicative media; and,

(C) To enact legislation ensuring not only that the confidentiality of tele-processing of computer programmes and files is assured but also, by means of a national archival repository[3], that the exclusive right to the authors of machine-readable versions of computer-directed programmes is secured for limited times.

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[1] Epigraph Afront the College of William and Mary's Swem Library—
'For Here We Are Not Afraid to Follow Truth Wherever it May Lead,
Nor To Tolerate Error So Long As Reason is Left Free to Correct It.
—Thomas Jefferson.

[2] 'The Whole Art of Government Consists in the Art of Being Honest' (Thomas Jefferson).

[3] AN EPISTLE TO DR. BENJAMIN FRANKLIN. New York: Exposition-University Press, 1975 (G. Arthur Mihram).

[4] For example: the tele-phone; the tele-graph.

[5] For example: Recordings of professional calls at both receivers;
Displays of Greenwich Mean Time and the originating receiver's number ("telephonic" postmark).

[6] For example: Radio, television, cable television.

[7] For example: Libel laws of tele-communications.

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* * *

ALASKA'S LEGISLATIVE TELECONFERENCE NETWORK

-- WHY IT WORKS --

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Recent inquiries about Alaska's Legislative Teleconference Network (LTN) are differing from earlier questions such as, "What is it?" and "How does it work?" A frequently heard question now is, "Why does it work?" This paper is a discussion of the LTN's continued operation and why it has become a valid, working communications tool for legislators and citizens alike.

In 1978, the Alaska State Legislature established an audio teleconference network that included six locations throughout the state: Juneau, the capital, Anchorage, Fairbanks, Nome, Ketchikan and Bethel. Since that time, the network has grown considerably and now consists of eighteen (18) Alaskan communities and Washington, D.C. In late 1978, video teleconferencing was also introduced and has since become an integral, though lesser used, part of the LTN services.

The Legislative Teleconference Network is a dedicated, 4-wire telephone circuit. It travels the same long lines system as the rest of Alaska's satellite-linked toll services with the exception that it is not a dial-up line. In its most basic form, the LTN is literally a shout-down, "whoop n'holler" line that is accessible twenty-four (24) hours a day, simply by turning on a Western Electric 50A1 conference set. The circuit extends from the long lines toll centers (Alascom, Inc.) in each community through local telephone facilities to an established or part-time teleconference center that is staffed by employees of the Legislative Affairs Agency. The legislative staff-person, (called a teleconference moderator), is charged with the responsibility of operating the state-owned conference equipment as well as assisting with the management of teleconferences and dealing with participants.

ADDITIONAL BACKGROUND AVAILABLE

In May of 1980, a presentation was made at the University of Wisconsin's Conference on Interactive Media, which described in detail the historical development of the LTN and a discussion of its overall success. Titled, Public Involvement in the Legislative Process through Teleconferencing, the paper stresses the impact teleconferencing has made on the legislative process in a state that has some unique circumstances.

UNIQUE, BUT...

Alaska is unique for a variety of reasons, thus it is very understandable why teleconferencing lends itself so well to the state's communications needs. However, much of what the Alaskan legislature has devised for its specific use, can indeed be altered for similar purposes in other states. In particular, large states such as Texas, Hawaii and California would find value in legislative teleconferencing, as well as those states with great population where pulling many people together to one location is often unwieldy or impractical.

To date, Alaska is still the only state to have a legislative teleconfernece system, with its primary purpose to increase citizen access to state government. Other states are showing interest in this application, and recent inquiries indicate particular curiosity in the fact that the Alaskan system continues to be very operational and functional practically every business day of the year.

WHY DOES IT WORK?

Why does it work? The simple answer, in this writer's opinion, is because the implementation of this network was never considered an experiment, as has often been the case in so many other telecommunications endeavors during recent years. From the outset in 1977, the task force that researched and then founded the network treated it as something that would indeed work and be dependable. They were not only charged with the task of figuring out what type of system to have installed, but also with the development of protocols and procedures to be followed by the users and moderators.

A great deal of initial capital expense was also involved, both for the state and Alascom, (then known as RCA Alascom), so of course fiscal responsibility entered into the picture as well.

But the sincere effort by the task force to develop a suitable system of a permanent nature seems to be the key factor to the LTN's lasting success. That's not to say there have not been difficulties along the way, nor growing pains associated with its rapid increase in use and size.

A SUITABLE SYSTEM

This suitable system we talk about cannot be described by simply "looking on page 22 of the Ajax Telephone Equipment Catalogue". As in just about everything else in life, it is not that simple. By "system" we mean more than the technical equipment involved, such as the dedicated cable, the special low-impedence bridges located in central equipment offices or the portable conference sets and mikes that plug into standard, modular jacks. The "system" works because far more is involved than the state-of-the-art and straight-forward technology that is its basis.

The system exists because there is a well-defined need to provide people with this type of communication and because those same people like using it. It is reasonable to say that the majority of the Alaskan teleconference participants are repeat users. That includes those persons who testify in special interest public hearings held by legislative committees to those who attend workshops or training sessions.

Additionally, the system works because the established protocols and policies administered by those who have been, and are now responsible for it, are good ones. The actual method of conducting a teleconferenced public hearing, for example, has repeatedly proven to be a successful format.

PHILOSOPHY

Another success factor seems to be the general philosophy, shared by legislators and staff alike, about protecting the overall integrity of the network. Legislators are pleased to have the system available to them and staff members share a certain sense of pride as operators of the system. Each moderator represents the LTN in his or her own community, thus having the unique responsibility and opportunity to act as liasion between the local citizens and state government. As well, moderators are also locally hired, well-trained to comfortably operate their own conference equipment and required to maintain a very nonpartisan and unbiased role in their positions. Enthusiastic and properly trained personnel are definite assets.

CONTINUAL USE

Perhaps a major contributing factor to the overall workability of the system is the fact that it is constantly used. The network is used daily, in between scheduled teleconferences, for administrative chatter and information exchange among the various teleconference offices. It is therefore constantly monitored for problems such as adverse line noise or interference which are reported to Alascom repair service immediately. Such efficient access to each site also allows for tight scheduling coordination, a particular boon during the busy legislative session, when there are sometimes five teleconferences a day.

Another dramatic plus, because the system is so far-reaching, is that a question asked by Nome, for example, and answered by Juneau, will be heard by all sites. This instant sharing of information has been helpful to staff many times over.

Juneau is the Teleconference Coordinator's office location, therefore, the control point from which troubles are reported, scheduling is done and to where inquiries are directed. This centralization of a circuit that covers thousands of miles is an important element for adequately managing it.

Daily use of the network also affords greater opportunity for improvements. Moderators exchange experiences, problems and new ideas with one another over the network and have instant access to the coordinator for assistance. Obviously, these same people have regular telephone service too, but the teleconference system is more spontaneous, efficient and cost-effective.

ARE COSTS JUSTIFIED?

It is important to consider costs involved with the LTN. The monthly cost to the State of Alaska for the entire audio network service is approximately $16,000. This figure represents a tariff that covers thousands of point-to-point airline miles and relatively high rates, in spite of the fact that by including Washington, D.C. the charges are based upon lower inter-state rather than intra-state tariffs. This figure is considered very cost-effective because cost incurred with travel and per diem alone would be considerably greater if the same public participation were possible without the LTN.

After three (3) years of operation, the Legislature and constituency alike have become very used to the LTN. Needless to say, travel money is not the only major savings that occurs when persons participate in teleconferences from their home towns. Time is saved also--time that would have been taken away from job and family, or would have been spent for research and written testimony. Citizens often report that they would not have taken the time to testify in a public hearing had the LTN not been so convenient and efficient. It is interesting to note too, that as communities become used to having the LTN, more people seem to participate more often and more spontaneously.

ENHANCEMENTS

There are numerous reasons then, why the LTN works: it is efficient, cost effective, personal, convenient, simple to operate and accessible to more than 75% of the state's population. It is also enhanced by facsimile capability that can include all sites at once when desired. Since most teleconference centers are located in Legislative Information Offices, an indirect enhancement is that these offices have access to two (2) legislative data systems; one that offers status on legislative bills, the other a form of electronic mail. This kind of instant back-up communication is a terrific additive to many facets of teleconferencing.

VIDEO TELECONFERENCING

Video teleconferencing should be treated as an entirely separate subject for any in-depth analysis. Briefly, video teleconferences are managed similarly to audio conferences along with the cooperation of the legislature's relatively new Media Center and other television studios in nine (9) locations throughout the state. It is more costly, more time consuming in terms of preparation and presentation and less used than audio. However, there are cases where video has great advantage over audio, and its popularity is growing, as is the Legislative Affairs Agency's knowledge of how to utilize it more effectively in the legislative process.

FUTURE PLANS

The LTN will not be "whoop n'holler" for much longer. Plans are underway to sophisticate the circuit by adding a selective signalling system. Manufactured by DANTEL, and to be installed by Alascom before January 1981 at all LTN locations, this new feature will enable actual calling. By dialing three-digit codes with the teleconference handset, a ring will be heard at the coded location thus advising the moderator to turn on the conference set. This will be particularly helpful to the Washington D.C. offices where it is not desirable to keep sets constantly "on-line". The signalling system will also allow for "sectionalizing", i.e. by use of group codes, only those sites to be included in a particular teleconference are called. On the other hand, all sites can be coded to remain on line indefinitely, should that be the desired case. With additional modification to the basic DANTEL equipment, there is the possibility of long term plans to enhance the sectionalizing feature even further, by enabling the circuit to handle more than one teleconference at a time. For example, while Juneau, Sitka and Ketchikan are teleconferencing, Fairbanks, Nome and Kotzebue could be holding a separate meeting on the network simultaneously.

In spite of new equipment additions and sometimes complicated scheduling, the Legislative Teleconference Network will no doubt continue to remain a simple and straightforward means of communication for the State of Alaska. Indeed it works thanks to modern telecommunications technology, but it has continued to operate successfully because of the many people who believe in the LTN and want it to work.

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BETHEL INFORMATION OFFICE
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P.O. Box 886
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DILLINGHAM INFORMATION OFFICE
Old Court Room, Combined State Fac.
Pouch 229
Dillingham, Alaska 99576
(907)842-5319

FAIRBANKS INFORMATION OFFICE
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Fairbanks, Alaska 99701
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*HAINES TELECONFERENCE CENTER
City Council Chambers, Mun. Bldg.
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Haines, Alaska 99827
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*HOMER TELECONFERENCE CENTER
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P.O. Box 883
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MATANUSKA-SUSITNA INFORMATION OFFICE
Parks Highway & Knik Road
P.O. Box 1470
Wasilla, Alaska 99687
(907)376-3704

NOME INFORMATION OFFICE
2nd Floor Conf. Room, State Bldg.
P.O. Box 1630
Nome, Alaska 99762
(907)443-5555

*SAND POINT TELECONFERENCE CENTER
(To be established by Jan. 1981)

*SEWARD TELECONFERENCE CENTER
City Council Chambers, City Hall
P.O. Box 737
Seward, Alaska 99835
(907)747-6276

*VALDEZ TELECONFERENCE CENTER
City Council Chambers
P.O. Box 713
Valdez, Alaska 99686
(907)835-2111

WASHINGTON, D.C. TELECONFERENCE SITES

Office of the Governor
Offices of the U.S. Senators (2)
Washington, D.C. Information Office

* On-call moderators--Contact through LEGISLATIVE COMMUNICATIONS NETWORK, Juneau.

The USPNet Outreach Programming: Evaluation and Guidelines for Future Use

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Abstract

The University of the South Pacific, in Suva, Fiji, has been using NASA's ATS-1 since 1972 for interactive Course Tutorials and to coordinate the administration of the University's Regional Extension Centres in the South Pacific. Recently the University has moved into initiating and coordinating a variety of development-related teleconferences utilizing USP's Satellite Network. This paper examines the progress of USP's move into Outreach programming, and offers suggestions regarding the utilization of an interactive satellite system for development-related exchanges.

1. BACKGROUND

In 1971, the University of the South Pacific (USP) in Suva, Fiji was one of the first Pacific institutions to join the then-developing Peacesat (Pan-Pacific Educational and Communication Experiments by Satellite) Network. The Peacesat planners had developed a successful model for low cost (ca. U.S. $5,000) ground terminals and had applied to the U.S. National Aeronautics and Space Administration (NASA) for the use of time on NASA's Applied Technology Satellite One (ATS-1). In a geostationary position over the equator, the ATS-1 has a footprint covering almost 1/3 of the earth's surface including all of the Pacific Basin. The satellite was launched in 1966 for a series of weather experiments but had outlived its usefulness, and in 1970 NASA approved Peacesat's request for non-commercial use. The Peacesat Network planners envisaged the development of an interactive, satellite teleconferencing network which would focus on the exchange of health, education, and community service-related information among countries in, or on the rim of, the Pacific Basin.

USP became a participating member of the Peacesat Network, when it activated a terminal on its Laucala Campus in Suva, Fiji in 1972. A second terminal was activated the same year at the USP Regional Centre in Nuku'alofa, Tonga.

In 1972, USP was in its infancy and had a responsibility not only for providing tertiary education in the South Pacific Region but also for being a focal point for regional development. This region included 1.5 million people living on numerous islands spread over 11 million square miles of ocean. Telephone communication in the Region was unreliable and mail delivery between Pacific Island nations could often take two to three weeks due to the infrequency of inter-island air service.

Within the context of the University's role as a regional institution, participation in a Pacific satellite communications network was undoubtedly appealing. The University participated in a variety of Peacesat-organised exchanges, but soon realised that one of the most important uses of the system was the link it provided for the developing USP Regional Centres throughout the South Pacific to discuss administrative and educational matters.

As the number of USP Regional Centres increased, so did the need to communicate with each on a more frequent basis. Prompted by this need, and at NASA's invitation, USP applied to NASA in 1973 for satellite time to be used specifically for USP's Extension Services Programme. NASA approved the request and allocated USP approximately nine hours per week to operate their own network, the USPNet.

In 1974, USP activated terminals at University Regional Centres in Niue, the Solomon Islands, and Kiribati (formerly the Gilbert Islands). Vanuatu (formerly the New Hebrides) was added in 1975, followed by Apia, Western Samoa in 1976, and Tuvalu (formerly Ellice Islands) in 1978. In 1979, a second terminal was activated in Western Samoa on the University's Agricultural Campus in Alafua.

The University also had access to a Peacesat Terminal in the Cook Islands, but added their own USPNet terminal in Rarotonga in 1979.

The early years of the USPNet were filled with a series of difficulties that often are associated with setting up a development communications project in a relatively remote area of the world, e.g., delays in equipment acquisition and in getting staff in place. However, the University managed to utilise most of the satellite time allocated by NASA. This time was devoted to University administrative and educational functions. Administratively, the network was proving to be invaluable in the daily operations of the University's Extension Services Programme. It provided direct and immediate contact between the University's Regional Centres and the Extension Services Office in Suva. Most of this satellite traffic dealt with course management and Centre administration; and gradually the network became recognized as the primary link connecting the main campus in Suva with the Regional Centres. In addition to this administrative function, students enrolled in USP Extension Study Degree Level Courses were being offered a unique supplement to their course material; that is, a satellite tutorial with their Course Tutor on the main campus in Suva.(1)

In 1978, USP proposed to both NASA and the U.S. Agency for International Development (USAID) to extend the USPNet experiment and to increase its scope. This was to be accomplished by upgrading the ground terminals to improve the quality and reliability of the transmission and reception, as well as by adding video, slow scan, and facsimile components to the system. After negotiations, the experimental project was approved by USAID, and NASA increased USPNet's time allocation to 23 hours, 40 minutes per week.

In accordance with the proposal objectives USP would use the increased satellite time to: 1) continue the administration of the Regional Extension Studies Programme, 2) continue providing satellite tutorials for students in the region, and 3) coordinate the dissemination of development-related information throughout the South Pacific Region.(2)

Of the three identified satellite uses, the first two (administration and course tutorials) were established University functions already facilitated through the use of the satellite network. However, the third area (dissemination of development-related information, referred to as the Outreach Programming) represented a new, experimental use of the telecommunication's network for USP.

2. THE OUTREACH PROGRAMMES

USP and its Regional Centres had been active participants in numerous development-related Satellite Exchanges since 1971 as part of the larger Peacesat Network. The two networks, Peacesat and USPNet, shared time on the same ATS-1, and USP had organised several projects, such as the Tourism Exchanges and the Precious Coral Series, which involved terminals from both networks. However, when USP's Extension Services began planning their Outreach Programmes for the latest phase of their Satellite Project, the coordinators realized there were very few guidelines available on which to base programme planning or long-range strategies. Consequently, a variety of satellite exchange sessions and formats took place during 1979 and 1980 on an experimental basis.

After a year of experimentation with satellite teleconferencing for Outreach and Development in the South Pacific, USP's Extension Services undertook a formative evaluation of the satellite programming during July and August 1980. The objectives of the evaluation were to provide Extension Services with information on the effectiveness of the past sessions, and to offer guidelines regarding how to proceed in planning for future satellite exchanges.

The following sections focus on: 1) the evaluation procedures used by Extension Services, and 2) the guidelines being utilized by USPNet for current Outreach Programming based on the findings of the formative evaluation study.

3. EVALUATION : EFFECTIVENESS CRITERIA AND METHODOLOGY

The effectiveness of satellite exchanges, particularly those designed for outreach and development-related purposes, has often been based upon quantifiable data such as terminal participation rates, the number of individuals participating in an exchange, which terminals, if any, dominated a session, and the number and type of messages passed during a scheduled session. More informal evaluations have been based on the Terminal Manager's, Terminal Operator's or Session Coordinator's perception of the structure of an exchange; for example, whether an adequate agenda was prepared, distributed to participants in advance of the session, and more-or-less followed. All of these criteria have contributed to an understanding of the satellite teleconferencing process. However, none of these effectiveness criteria offers information on the participant's perspective regarding the usefulness of the information exchanged or the quality of the session. This inevitably leaves a large gap in the information needed to plan future exchanges.

To evaluate the qualitative aspects of USPNet's Outreach Programming from the perspective of the participants and organisers of the sessions, forty-six interviews were conducted over a period of two months in four USP regional locations -- Fiji, Tonga, Niue and Western Samoa. Those interviewed included: 3 USP Centre Directors, 2 Satellite Programme Officers, 1 Tutorial Assistant, 11 Coordinators of Satellite Exchanges, 28 Exchange Participants, and USP's Co-ordinator of Learning Resources and Communication. Names of session participants and coordinators were obtained from USPNet Satellite Exchange files kept at the Suva terminal.

Interviews lasted an average of 45 minutes and focused on:

1) planning and implementation of satellite exchanges

2) formats utilized

3) the process for identifying regional participants

4) defining goals and objectives

5) distribution and use of agendas

6) perceived impact of the USP Satellite Project in the South Pacific development process

7) problems and successes of past exchanges

8) information needs in the South Pacific.

Most of the exchange participants and coordinators selected for interviews participated in two or more USPNet sessions on health, labour, or agricultural topics. These three categories were chosen as a basis for evaluation because each represents a series of exchanges and a variety of formats. In addition, these sessions were clearly identified as having been originated by the USPNet.

The health-related exchanges were organised by USP in conjunction with the World Health Organisation (WHO) Office in Suva. WHO had used the satellite system to exchange medical information during outbreaks of dengue fever, Ross River Fever, and cholora in the South Pacific in the mid-1970's. Impressed with these emergency uses of the Network, WHO was interested in experimenting with the interactive satellite communications system for health-related educational, and administrative exchanges in the South Pacific Region. The sessions conducted by WHO during 1979 and 1980 were often regarded by the USP Project Coordinators as examples of successful Satellite Outreach Programming. This perception was based primarily on high participation rates, well-detailed agendas, and tightly -organised sessions.

The labor-related exchanges were similar to the health exchanges in that they were organised by USP's Extension Services in conjunction with an international organization in this case the International Labor Organisation (ILO). ILO was interested in using the system to stimulate discussions and to exchange information among South Pacific Island Nations on topics such as Trade Testing, Marine Employment, and Labor Administration.

The agricultural sessions included in the evaluation were two major series, Crop Protection and Agricultural Marketing, and several point-to-point exchanges. These agricultural sessions were particularly important in the evaluation process because they were coordinated primarily by USP through Extension Services on the Laucala Campus in Suva, Fiji, and the School of Agriculture on the Alafua Campus in Western Samoa. Both agricultural series attempted to tap expertise in the region by inviting agricultural authorities in the South Pacific to prepare a discussion paper on a pre-identified topic. The paper was distributed to interested persons in each terminal country, and a satellite discussion session was scheduled.

4. FINDINGS AND GUIDELINES FOR FUTURE EXCHANGES

During the interview process, it readily became apparent that any one satellite exchange session cannot satisfy the needs of every participant; information needs inevitably vary among participants as well as among countries. Those interviewed were not unanimous in their support or criticism of any particular exchange or format.

The following points and guidelines currently being implemented by USP's Extension Services, are based on the general responses to the exchanges, as well as on the experiences of the Project Planners with coordinating Outreach and Development-related programming for an interactive satellite system. As such, the information can serve as a basis for other projects involved in the utilisation of similar interactive communication systems for Outreach and Development goals.

4.1 FORMATS

Although a wide range of Satellite exchange formats are possible, most of USP's Outreach Programmes fit into one of the following two structures: 1) presentation of a lead discussion paper or paper summary followed by a discussion period with questions from participants in the Region, or 2) information-gathering sessions where participants at each terminal were requested to be prepared to give a report, e.g., describing disease control techniques, regulations on pesticides, or training procedures for tradesmen.

Infrequently other formats were used, such as: 1) pre-workshop sessions where participants were briefed on how to prepare for a workshop before leaving their countries, 2) post-workshop sessions where participants who have returned to their country discuss via satellite the use and effectiveness of new techniques or strategies, and 3) a resource person or consultant visiting the region conducts a satellite session with interested participants in other countries. Most of these sessions fit into a one-hour framework.

USPNet has found that the following points contribute to successful multi-point exchanges:

1) Introductions. Keeping introductions brief by identifying the key participants only. Excessively long introductions cut into the valuable exchange time and USPNet coordinators have found it useful to remind terminal operators at the beginning of each session to keep the introductions to a minimum.

2) Number of Participants/Length of Session. The length of the introductions is directly related to the broader question of how many terminals and persons can successfully participate in a one-hour session. The answer often is dependent on variables over which the coordinators of a session have some but not total control, such as the number of participants who ultimately attend a session, and participants exceeding the prescheduled time limits set for individual responses. USPNet coordinators and users have found that more than five actively participating terminals for a one-hour session tend to have a negative effect on the interactive process. For example, with several participating terminals, the possibility of a question left unanswered is greatly increased.

   When larger multi-terminal sessions are a necessity, as is often the case with WHO and other international organizations, the USPNet has attempted to schedule 90-120 minute exchanges by trading allocated time blocks with the Peacesat Network. These longer sessions tend to maximize the possibility that all terminals will be able to participate actively. During 90-120 minute session the USPNet has scheduled mid-session breaks of about five minutes. Participants have reported that this is a useful procedure for organizing questions and responses at each terminal.

3) Agendas. The frequency of problems such as long introductions, and domination of a discussion by one or two participants, can be reduced through detailed agendas

distributed to participants well in advance of the session, as well as through the efforts of an assertive chairperson (discussed below). Agendas should include not only a general outline of the session's discussion points, but also the amount of time allocated to each point, time limits for individual responses at each terminal, and, if possible, several minutes at the end of a session for open discussion. Since this approach also curbs the spontaneity of a exchange, it is used primarily to maintain structure in larger multi-terminal sessions.

4) Discussion Papers. Discussion papers, like agendas, need to be distributed well in advance of a scheduled session. This has not always been the case with USPNet Exchanges and, as a result, lead papers frequently were read at the beginning of the scheduled exchange. Not only is this an ineffective means of communicating ideas, but it often proved to be "boring" to the participants. Therefore it needs to be stressed in the planning stages that lead papers be received by participants at least three weeks prior to the session. If the paper is received by participants in advance of the exchange, the discussion coordinator can give a brief outline of the most important points and move directly into the discussion.

5) Chairperson. It is particularly important to designate a chairperson who is familiar with the satellite exchange process (most often this is not the author of a lead paper) and who can keep participants within the time limits of the agenda. It has been suggested by users that the chair be rotated so as to deemphasize Suva's domination of the Network. However, a strong, assertive chairperson contributes to the success of an exchange, particularly in multi-terminal sessions. Therefore USPNet coordinators are currently using either the Satellite Programme Officers in Suva or Alafua to chair all Outreach Programmes.

4.2 SERIES LENGTH

The length of any series will usually be determined by the objectives of the exchanges set during the planning process. However, participants in USPNet Outreach Exchanges generally felt it best to limit sessions to five per series with the option of continuing the series, if desired. Five sessions per series are a workable number in terms of planning as well as evaluation. In addition, most participants did not want to commit themselves to longer periods of time.

4.3 PROGRAMME PLANNING PROCEDURES

During the initial stages of implementing USPNet's Outreach Programming, most series were developed through the initiatives of the Satellite Programme Officers. While this was a workable method for programme initiation in the early phase of the project, it became increasingly apparent that programme priorities needed to be established. This was particularly important due to two factors: 1) available satellite time for Outreach activities was rapidly being filled, and, 2) it was anticipated that initiatives for satellite programme series eventually would be coming from USPNet member terminals other than Suva and Alafua.

In response to these needs, a Programme Planning Advisory Committee was created. The Committee, composed of all Programme Officers and Division Coordinators at Extension Services, is concerned with a variety of tasks which includes the review of proposed satellite exchange series. Any proposed satellite series involves the following steps:

1) Proposal is submitted to the committee and includes information regarding objectives, project rationale and needs, anticipated series length, format, identification of participants, project coordinator and evaluation procedures.

2) Committee discusses project feasibility, and suggests revisions, if necessary.

3) Project is accepted, rejected or postponed.

4) If accepted, recommendation is made to the Division Coordinator and planning sessions are scheduled.

5) Pre-exchange planning takes place with identified participants and, if not previously completed, a needs assessment session is conducted via satellite; proposal structure and objectives are clarified and reorganised incorporating feedback from potential participants.

6) Revised project proposal reviewed by advisory committee and participants.

7) Sessions are conducted.

8) Proposed evaluation is carried out with participants and terminal managers.

This procedure currently is being followed for any proposed satellite series, and is intended to help clarify project objectives, to limit the number of series scheduled within a six month period, to avoid overextending production personnel, and to obtain input from all interested staff members.

4.4 PARTICIPANTS

Identification of the appropriate participants is crucial to the success of the exchange. The WHO-and ILO-coordinated USPNet exchanges often are identified informally as successful examples of satellite teleconferencing. A reason contributing to this perceived success is the uniformly high participation rates at every scheduled session. Two factors associated with this high participation rate are: 1) WHO and ILO are both international organisations and know the names of most of the participants they want to reach, and 2) the organisations contact participants twice, once by letter and once via satellite through a request to the Regional Centre Director.

The USPNet exchanges coordinated solely by Extension Services, such as Crop Protection and Agricultural Marketing, have been marked by relatively low participation rates. The major problem with these series has been the inability to identify appropriate participants. For most sessions the Regional Centre Directors were sent a general outline of the series and were requested to locate the appropriate person in their country; e.g., the person in charge of agricultural research. This approach has not been particularly successful since Centre Directors often were not able to locate the appropriate person and sometimes were not entirely clear regarding the objectives of the proposed exchange.

Currently the USPNet is attempting to alleviate the problem associated with audience identification by compiling a list of regional resource people who may be interested in future sessions or who may know of others in their country who would be interested in attending sessions. A comprehensive cross-listing of persons by name, job, agency of employment and past participation in satellite sessions becomes an invaluable aid in identifying future participants. It is anticipated that this identification of participants prior to the initiation of a series will facilitate the planning and needs-assessment processes.

4.5 REGIONAL COORDINATORS

The USPNet has been relying on the University's Regional Centre Directors in their role as Terminal Manager to coordinate the satellite exchange process in their countries. While this was effective during the early stages of the project, it has become clear that as more satellite exchanges are being implemented, Centre Directors cannot adequately organise all scheduled sessions. In recognition of the time committment necessary to coordinate exchange participants, to assess local development-related needs, and to design and organise appropriate programmes to meet these needs, the University has considered locating Outreach Officers/Terminal Operators at the larger terminals. The first Outreach Officer will be placed in Western Samoa on an experimental basis early in 1981. It is anticipated that the addition of full-time Outreach Officers will increase the effectiveness of the development programming.

4.6 GUIDELINES FOR USING THE NETWORK

Due to the uniqueness of using a multi-point radio system for interactive conferencing, there is a need to provide potential users with a range of introductory and pre-exchange information. USP's Extension Services has been informally briefing satellite users during the planning process on the following points:

1) how to plan and organise satellite exchanges

2) identification of participants

3) approaches to writing lead and

discussion papers

4) methods of assessing information needs, and interests of participants.

5) translation of user needs into satellite programme formats.

6) identification of practical satellite uses and formats, such as information and data gathering, administration of field projects, and follow-up to courses and workshops.

7) appropriateness and potential of integrating other technologies available to the USPNet, such as videotape, slow-scan, and microprocessors.

8) equipment familiarization sessions for new users.

5. CONCLUSIONS

The coordinators of the USPNet have realized that the prime importance of the Network to date has been in the areas of regional education and University administration. These may well be the areas where the most fruitful interactions will take place in the future. However, if USP intends to use a satellite teleconferencing network for development and outreach activities in the South Pacific, a more coordinated and structured approach is needed to attain these goals. The future of the Network depends, to some degree, on the Project coordinators' acceptance and implementation of the recommended guidelines, as well as on the adequate assessment of regional needs, the planning of programmes appropriate to meet those needs, and continued programme evaluation.

The impact of the Network on the development process in the South Pacific is difficult to assess at this stage of the Outreach programming. However, it was apparent during the interview process, that people in the Region are accepting and using this new mode of communications. Many valued the sessions highly and regarded the exchanges as a primary means of obtaining professional level information. When queried at to the type of exchanges that would be most valuable, a majority of users identified sessions which would fit into the broad definition of continuing education and which would help professionals upgrade and expand their skills. A move in this direction for the USPNet would demand additional resource allocation and time devoted to the coordination of the satellite programs. However it is not beyond the potential of the satellite network to deliver such information.

Despite the criticism that a satellite network such as the USPNet primarily reaches the elite, there is little doubt, in the opinion of the users, that the USPNet has contributed to getting new ideas flowing throughout the Pacific. The value of the system varies from country to country, and it would be safe to generalize that the smaller and more isolated the island nation, the more important the system is to the users. Perhaps the largest impediment to more intensified satellite system utilization is the inaccessibility of a terminal. Although all terminals are located in each country's major population centre, many persons who might participate in a session cannot always get to the satellite centre. For example, rural agricultural and health workers who could benefit from a particular session are often too far away to travel to the terminal site for a one-hour session.

With regard to developing formats for Outreach programming, it is clear that there is no one formula for a successful interactive multi-point radio conference; every project, series, and exchange has different objectives and needs. What works in one situation with a particular group of users may not always work in another situation. It becomes the responsibility of the Satellite Programme Officers to identify needs and objectives and work closely with the users in designing and evaluating the programmes.

Even if the guidelines and points listed in this paper are followed, there are a number of other factors which have the potential to transform the USPNet. The major changes may lie in the integration of the new technologies of slow-scan, facsimile, and microprocessors, as well as in Extension Services' new videotape production capability. The introduction of and experimentation with these new technologies not only will alter the USPNet exchange system but also will demand more planning and development of programming by the coordinators in order to reach the defined objectives of the Project Proposal.

Some projects currently under discussion include: 1) the use of a microprocessor interface with the satellite for data gathering by international organisations in the South Pacific, 2) the development of formal and non-formal courses which utilize videotape playback to be followed by a satellite discussion coordinated from Suva or Alafua, and 3) the development of an agricultural information network which will rely on point-to-point exchanges and the microprocessors for information distribution.

It is precisely these combinations of uses that are important in developing a functional communication system. With this experimental phase of the USPNet due to end in December 1981, it is imperative that the experimentations continue in order to plan efficiently for an optimal operational system. What form that system will assume remains unclear, but discussions are underway regarding potential access to the planned domestic Australian satellite, as well as the currently functioning Intelsat system. At any rate, the University is convinced that some system is necessary to continue the flow of information among the island nations of the South Pacific.

FOOTNOTES

(1) This tutorial use of the USPNet was examined in 1979 (see: S.L. Rice, "Effectiveness of Satellite Tutorials", Pacific Telecommunications Conference Proceedings, P.T.C. 1980, Honolulu, Hawaii. pp. 3K-35 - 3K-39). It was found that the satellite tutorials were generally used as a supplemental and not an integral part of the course material. Students as well as tutors needed to develop skills in using an interactive, teleconferencing system.

(2) In addition, the University was required to: 1) evaluate the effectiveness of the various communications technologies (satellite, video, audio, slow scan, facsimile, and the recently added microprocessing capacity) in facilitating the achievement of the proposals objectives; 2) identify the University's regional communications requirements; and, 3) plan for the transition from experimental to operational service.

TELECONFERENCING NETWORKS FOR DEVELOPING SOCIETIES: A BRIEF ANAYLSIS

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Abstract

Teleconferencing systems utilizing full motion video and voice communications may be a technology which can bring education and training to large numbers of rural inhabitants in developing societies. Problems common to developing societies, those of cultural isolation, education, undifferentiated social organization and an absence of value systems that lead to the development of an industrial economy are the very conditions which can be best served by a decentralized network of regional, 2-way tele-communications systems. The Irvine Unified School District in Irvine, California has pioneered the development of 2-way television. Its decentralized 2-way communications network could serve appropriately as a model communications system for developing countries.

The Irvine Unified School District began to explore the potential of 2-way communications technology as a result of its conviction that the generation and processing of information of all kinds will play an increasingly important role in our society, and that new communication technologies (fiber optics, 2-way CATV, satellite, personal computers and video disc) will make it possible for large segments of the population to have access to extremely powerful information resources. For educational institutions in general and educators in particular, this rapid democratization of information will signal a radical transformation of the way learning takes place. Those who are in our schools today will enter a future increasingly dominated by telecommunications networks. The potential social dislocations caused by the selective implementation of these systems should merit careful monitoring by anyone concerned with education and social justice. It is the Irvine Unified School District's view that educators should be in the vanguard of helping to shape the use of these technologies in a humane and democratic manner. The task begins with education and with the institutions charged with the responsibility for providing the fundamental life experiences upon which freedom, opportunity and democracy can flourish.

The Irvine 2-way cable television network, its philosophy and its means of implementation, has important implications for any environment where the need for communication and the need for the transfer of cultural information is great. The following discussion is intended to merely touch upon some of the fundamental issues relating to the utilization of telecommunications technology in developing societies. These issues are extremely complex and properly require much more extensive treatment than I have been able to give them in the paper. However, it is a beginning and perhaps its relative brevity will stimulate further debate.

It must be recognized that the historical precedents for the use of high technology in developing countries are not particularly encouraging. Attempts to implement sophisticated systems in what are essentially pre-industrial or marginally industrial societies have met with only limited success. This is due in large measure to a common misapprehension of the underlying conditions affecting the success or failure of efforts to bring massive, capital intensive technology to essentially agrarian cultures. These conditions are the manifestation of extremely complex social forces that are not always addressed by the industralized world as their infusions of capital seek to catapult developing societies into the twentieth century. It is not within the scope of this paper to attempt to analyze either the origin or the influence of these social forces on rural societies but, rather, to identify some of them and to discuss them in the context of how the application of technology appropriate to the needs of people can help to bring about the kind of social and behavioral changes which eventually will provide the framework or infra-structure upon which industrialization in the modern world depends.

When identifying the kind of development most suited to a developing country, the critical issue to examine is whether or not the needs of the indigenous population are being met. Historically, the failure of massive aid programs has been that they have been concentrated in the wrong sector of the population. They most often have addressed themselves to the needs of a small, powerful elite; those who, in many instances, have been educated abroad and who already possess the value systems and motivations of developed societies. Large scale aid programs typically do not address the educational and behavioral needs of the masses, who tend to be agrarian, uneducated and lack the discipline required to succeed in a modern, integrated economy.

The purpose of this paper is to identify some conditions common to developing societies, conditions which generally prohibit them from rapidly developing an industrial capability, and to offer some suggestions as to how these conditions can be altered given the utilization of appropriate technology. It must be noted that, in this context, communications technology can be thought of as a vehicle, a process by which large segments of the population in developing societies can acquire the skills necessary to sustain a self-generating, self-sufficient economy. In this paper, I will use as a framework for discussion an economic model advanced by E. F. Schumacher which states simply that developing societies require unique technology - technology that is labor intensive rather than capital intensive, technology that provides jobs to match the excessive labor requirements of emerging societies, and technology which is intermediate in nature and tends to develop not only applied technical skills, but builds literacy, organizational skills and value constructs that are perhaps the most critical elements in the development of a modern industrial state. (1)

If one examines the conditions extant in developing countries, several characteristics seem common to each. The first and most evident is the existence of dual economies; highly modern urban centers where the concentration of technology has created a veneer of industrialization and large, undeveloped rural areas existing side by side. The rural, agrarian economy often exists at a subsistence level, and it tends to permeate the majority of the population. It is not uncommon to find less than 15% of the population living in urban centers, the remaining 85% living at a subsistence level in the surrounding countryside, with relatively few links to the industrial centers and almost no access to education or to opportunities to acquire skills so that they might contribute to the total economy. The result is that most are denied access to the tools of change and a chance to improve their lot. (2)

The instability of these economies is often directly related to the dearth of skilled technicians and a broad based indigenous managerial class. However, the abject reality is really only symptomatic of underlying problems common to all developing societies. Most importantly, for developing societies to move toward industrialization, they must possess certain characteristics, certain behaviors that contribute to the successful development of industry, to the establishment of small business and to the support of a merchant class. If a society lacks education, if it lacks sufficient organization and internal cohesion, and if it lacks the discipline to sustain a market economy, then no matter to what degree the infusion of capital from without, the economy will founder.

Schumacher contends that the evolution of development in these societies tends to overlook the most important pre-conditions of success which are generally invisible. "If we do not entirely overlook them, (pre-conditions), we tend to treat them just as we treat material things; things that can be planned and scheduled and purchased with money according to some all comprehensive development plan. In other words, we tend to think of development, not in terms of evolution, but in terms of creation." (3) But the simple truth is, development is evolutionary and intermediate and it cannot be implanted upon a people who lack the fundamental industrial pre-conditions of education, organization, and discipline.

If one accepts these aforementioned pre-conditions to be accurate assessments of the general state of third world societies, then one must seek an appropriate set of technologies which not only can aid in the development of a primitive market economy, but which can also instill within the indigenous population basic education, a sense of organization and structure, and value constructs that lead eventually to personal mobility and to a fully integrated industrial state. These pre-conditions are evolutionary in nature. They cannot be purchased or imported through colonial elites. If the economy remains artificial, if it remains solely in the hands of a small managerial elite, then real growth can only be sustained by ever greater infusions of capital and technology. Thus, it appears that the only long term solution is to gradually instill within the indigenous population skills and organizational techniques which can sustain an integrated economy.

This suggests that the most critical long term need for developing societies is that of mass education. Through education, organizational skills, discipline and values appropriate to an industrial economy can gradually be realized. Education is most fundamentally the result of communication that provides access to information. In developing societies, it is all too common to find that urban centers possess many of the conveniences and services of modern societies, but that these services are never carried into the countryside, primarily because communication and transportation systems remain primitive, and regional differences between various elements of the indigenous population are so great that communication between geographically isolated rural areas as well as between rural and urban centers is extremely difficult.

In a conventional sense, linking geographically isolated areas by constructing roads and highways represents a massive undertaking requiring tremendous amounts of capital, not to mention the investment of time, labor and energy, the combination of which make it virtually impossible to undertake within any reasonable timetable. One alternative is to create electronic transportation networks that can bring rural people the benefits of centralized urban communities. The potential effect of these electronic highways could be to slow the migration of rural people to urban centers, maintain the population in agrarian districts and yet provide education and opportunity to people who could remain close to their family or tribal communities.

From the recipient's point of view, telecommunications systems could provide a link to opportunity, yet do so in such a way that they remain in comfortable, supportive environments, environments in which they can retain their ethnic identities. Electronic networks such as these could effectively reach outlying groups with education and training which is the foundation of success in a society growing increasingly complex through its inevitable exposure to cultures of the developed world.

Rather than dislocating one culture in favor of another, 2-way telecommunications networks can retain elements of both by providing instruction in a natural, contextual setting. From the disseminator's point of view, a single individual or group of individuals responsible for education and training perse can reach far greater numbers of people via telecommunications than they could if they were required to physically transport themselves to several villages. With telecommunications systems, particularly if they are 2-way video and permit interaction between parties and among parties, the capability for a single instructor to spread himself electronically over these same villages minimizes physical displacement and travel requirements and maximizes the effective outreach.

If one accepts the notion that the inculcation of education, organizational skills and discipline are the most important pre-conditions which lead eventually to the successful implementation of an industrialized economy, and if we accept the notion that telecommunications systems might be one effective means of speeding the development of these pre-conditions in indigenous populations, then it seems appropriate that we examine telecommunications technologies that might be successfully applied and the reasons one technology, in my view, is preferred over other alternatives.

One must, to whatever extent possible, take advantage of the novelty of technology. For example, by using technology as a vehicle for communication, the technology itself can serve as a motivational tool in bringing people to the system. In this example, education is almost a by-product of the natural curiosity created by the technology. In developing societies, if the telecommunications systems are designed for lay use, then regardless of the sophistication of its internal components, the technology can be used successfully by marginally illiterate people.

If one examines the literature relating to the effectiveness of various technologies in the transfer of information, particularly those studies done by NSF in Spartenburg, Reading and Rockford (4) in the early seventies, one can draw the conclusion that, for example, 1-way video with audio return is sufficient, and in some cases, 2-way audio only is an adequate vehicle for instruction. However, in these studies, as with most studies of the efficacy of telecommunications technology, there are several variables which may have skewed the results. Chief among them is that in none of the experiments did the participants have sufficient experience with interactive telecommunications systems, other than with 2-way audio (telephone), to become comfortable with them prior to the experimental evaluation of the technology. That is, none of the experimental groups had sufficiently sustained experiences with the modes of communication to ever reach a point where they considered the technology to be a part of the means of communication rather than artifice which, because of its unfamiliarity, continued to distract and inhibit communication. Quite frankly, the social acceptance or perceived acceptance of specific technology is a major variable, and not until experimental groups have prolonged experience with technology will the sociology of use and the efficacy of any communications technology ever be validated.

Second, uneducated and essentially agrarian people will come to this technology with entirely different life experiences. When selecting appropriate technology for developing societies, we should be mindful of potential cultural differences and that what may be sufficient in one context, between users who share the same culture, may be entirely inadequate and inappropriate when applied in another context. Given the developmental differences between cultures and that the information transfer, though focussed on basic literacy or upon the transfer of specific technical skills, will really represent cultural information and the entire process will be laden with cultural ques and cultural symbolism.

Under these circumstances, in my view, it is critical that 2-way telecommunications systems have real time, full motion video and audio capabilities, not only for effective instruction and demonstration but also, and perhaps more importantly, for the social and cultural transfer that can create an integrated contextual relationship between the recipients and the initiators of programs. In any learning situation, the most important variable is the student-teacher relationship. One-way, or even 2-way audio technologies delimit interaction between learner and instructor and do not allow the development of inter-personal relationships which, in our experience, is critical to sustaining the successful transfer of information.

It is through modeling of behavior that appropriate attitudes will be shaped. Two-way interaction with full motion visual information can serve as a medium for behavior change and will speed the process of cultural assimilation. In Schumacher's model for economic development, behavioral change through education is the most fundamental need of developing societies. (5)

If the communications technology were designed for 2-way video, it is quite possible that the process of education can be truly interactive; that is, the so-called dominent culture, rather than thrusting its own cultural bias' upon the developing culture, could seek solutions to mutual problems by combining the positive attributes of the indigenous culture with the potential solutions of the dominent culture. Wherever possible, the dominent culture should (and could with 2-way video teleconferencing, full graphics, etal.) reinforce solutions born out of the indigenous culture. As Schumacher has stated, "when rural, uneducated peasants learn that their time and labor have value, they will seek to increase its value by making it more productive." (6) By doing so, they will be practicing a most fundamental economic principle, that of conservation. Conservation is, in effect, a demonstration of deferred gratification and a building block of modern industrial economies.

It may be appropriate at this time to discuss an innovative 2-way cable television project in its sixth year in Irvine, California that could well serve as a model for decentralized telecommunications systems for developing societies. Throughout the discussion of the Irvine Project, parallel applications to developing countries can be explicitly drawn.

The Irvine Project has proceeded from the philosophical basis that in the application of technology to the problems of education, there has been an almost exclusive emphasis on highly condensed, processed content, produced and distributed by "professional" educators who, a priori, decide what is appropriate subject matter. In this approach, people far removed from the educational process decide what others need and then use technology whether it be books, tapes, or television to feed it out to the masses. Conversely, it is our assumption that all learners have things to contribute to their own learning and to the learning of others, and if we look in a larger context at America's social problems, our problems are not one of a failure of education in a technical sense, nor are they one of a failure of education in the informational sense.

If there is a failure, the failure lies in the ability to produce self-actualizing, thinking young people who believe enough in themselves to look into an area of interest, gather what data they can, reach some decisions about what should happen and then have the courage to act. (7)

In developing societies, this same resourcefulness, if you will, is often a matter of survival. The task then is to channel this resourcefulness into entrepreneurial know-how, to provide resources to generate initial productivity and to assist in the development of mutually supportive regional markets.

The Irvine 2-way CATV network is a decentralized system ideally suited to the conditions existing in many developing societies. The challenge in Irvine has not been that of adopting the technology but rather in learning to apply its tremendous potential most effectively to develop self-actualized, responsible individuals.

More specifically, the conceptual basis from which the Irvine Interactive Video System proceeds is that productive learning and information exchange takes place when communication technology provides the following: economical, one-to-one interaction among learners and teachers or learner-to-learner; two, access to information resources beyond the physical limits of the school or neighborhood site; three, personal control of and responsibility for learning, influenced by choice of time sequence and open access to alternate information resources; and, four, fluid time with personal rather than mass or group constraints upon the traditional idea of classes at scheduled times with narrow limits to content.

Programming in the Irvine Unified School District has evolved from the preceding conceptual basis. The technical development of the system followed our conviction that communication technologies need to reflect ideal, democratic, social processes. (8)

Therefore, we have developed over the past six years an extensive 2-way cable television network that, by design, changes the way in which we use technology. The system shares none of the trappings of professional studios or traditional productive techniques. The network uses inexpensive consumer quality hardware to link twenty-two schools in the district, the public library, the city hall and the University of California, Irvine with 2-way interactive television.

The system is decentralized. Each school is capable of transmitting its own video signal over one of two channels leased from the local cable company. Thus, each school can share its resources with any other school or any other combination of schools in the district. If we use a third public access channel, anyone in the community can watch school programs, and, if desired, interact 2-way via conventional phone lines.

The primary function of a decentralized, democratic communications network is to move away from traditional 1-way programming where the viewer receives passively whatever is on the air. In our view, a far more dynamic use of the medium is to create an active, participatory system where the viewer and the originator communicate in real time, where the viewer has an equal responsibility for the content of the program and where the roles of each participant fluctuate between reception and creation in a fluid, continuous mode of interaction.

Connecting an entire city with 2-way cable TV offers exciting opportunities for bringing people together via electronics to share personal expertise, interests and philosophies. The potenial of this medium to meet the needs of special populations: the disabled, the aged, youth who have transportation problems, educators, industry, and public organizations is, in our view, unparalleled.

The 2-way system in Irvine is in daily use providing opportunities for students, teachers, administrators and community residents throughout the entire school district to interact in a personalized, humane manner. Using simple access protocols, the system operates smoothly, with users themselves switching from one school to the next by simple oral commands. Each site can originate programs. There is no central studio and no site has the technical capability to eavesdrop on another without prior acknowledgement.

Teachers use the system for in-service training, exchanging ideas, offering mini-courses in subject matter of personal interest, team teaching in the basic skills and for role playing in developing values. Administrators conduct administrative meetings without leaving their schools; they bring in local experts to share their expertise with learners throughout the system and they offer occasional programming to the community to showcase special school programs.

For example, some schools report their achievement test results to the community via cable television and receive questions by telephone. School psychologists conduct guidance clinics over the community access channel and answer questions by phone. They also hold weekly meetings to coordinate programs operating at multiple sites within the district.

Students use the system to share ideas, projects, special research, hobbies and learning games. The interactive system fosters communication at all levels. Students are in entire control of the system, from organizing and planning programs to setting up, operating cameras, microphones, video tapes, channel selectors and signal modulators.

The technical apparatus of a 2-way cable unit is simple enough to be understood and operated by eight-year olds, and this is done daily in our system. The equipment is extremely durable and maintenance problems are kept to a minimum.

In the spring of 1978, the school district joined with Control Data Corporation in an effort to explore potential uses of 2-way interactive cable TV and PLATO, Control Data Corporation's sophisticated computer-based education system. In combination with the 2-way television system in Irvine, the computer, with its powerful information base, adds an entirely new dimension to live 2-way dialogue. With full implementation of the combined system, users could conceivably conduct programs over the 2-way cable, consult the computer periodically for data or instruction, engage in simulations, information gathering, or any number of variations.

The economics for delivering information resources are always of critical importance. If the school district were to use the head end of the cable system as the computer communication link, then, using teletext hardware to distribute data along the unused portion of the video signal on the cable, (the vertical blanking interval) computer costs could be reduced to only a fraction of what they are with standard telephone delivery.

For developing countries, new digital technology could permit interactive video systems to use standard PBX lines or conventional microwave and satellite communications for long haul transmission. Where spectrum is scarce, it appears that new technology may reduce band width requirements and make full motion video an economical means of bringing education and training to rural communities.

Rather than create a national education television network, which is the conventional use of television capabilities, the development of small district or regional interactive systems, each connected to an urban center, would maintain the integrity of local culture and language and would provide rural areas immediate contact with and utilization of the resources of industralized centers. Conceivably, each interactive "district" could be interconnected to create an electronic web linking urban centers and rural districts throughout the country.

Keeping the district networks small would enable communication to remain colloquial, intimate and personalized. It also suggests that programming could be more spontaneous, the result of a specific need rather than guided by an inflexible, pre-determined schedule. The concern at all levels of development is to keep the use of the technology humane and inextricably bound with the needs of the indigenous population.

Finally, unlike most projects utilizing high technology, the Irvine Project does not depend on highly skilled technicians to operate and maintain the system. Schumacher argues that if the technology is intermediate and appropriate to the needs of the people, there will be no difficulty in finding individuals equipped to operate it or in finding those who can be easily trained to do so. (9) Our experience in Irvine tends to support this position. Our simple technical design requires that the community participate actively as a resource for programming and as a participant in the process. This suggests that, by virtue of its technical design, individuals can be subtly induced to acquire skills and know-how they might otherwise avoid because they perceive it to be technically sophisticated and complex.

Ultimately, whether or not developing societies survive with any recognizable elements of their indigenous culture intact is dependent to a great extent upon how the transition toward modernization takes place. If it requires the implantation of external cultural values and a massive importation of technology that must be run by foreigners and maintained by foreigners, then the prospects for assimilation are fraught with difficulty. However, if one remains sensitive to the human needs of these societies, appropriate technology applied in a simple, constructive fashion can successfully accelerate transitional development and simultaneously reinforce and sustain native culture.

(1) E. F. Schumacher, "Small Is Beautiful," (Harper & Row, Publishers, Inc., 1973), p. 163 - 295.

(2) Ibid., p. 164.

(3) Ibid., p. 166.

(4) Charles N. Brownstein, "Interactive Cable TV and Social Services," Journal of Communication, (The Annenberg School of Communications, 1978), p. 142 - 201.

(5) Opcit., p. 168.

(6) Opcit., p. 177.

(7) A. Stanley Corey, Public Hearing, (House Subcommittee on Science, Research and Technology, October 9, 1979), p. 2.

(8) Ibid., p. 3.

(9) E. F Schumacher, "Small Is Beautiful," (Harper & Row, Publishers, Inc., 1973), p. 185.

Using the Satellite for Course Delivery in the Pacific: A Northern Marianas Experiment

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Abstract

This paper describes the experience, effects, advantages and disadvantages of the offering of a satellite course on Saipan in the Mariana Islands. The Course, "Politics of the Future" was offered in the Spring of 1980 as a experiment with alternative delivery systems of teacher training.

1. INTRODUCTION

The Commonwealth of the Northern Marianas, because of its island make up and distant location from colleges and universities must seek as many practical methods of offering training as possible. In order to get a practical understanding of the advantages and disadvantages of satellite use as one of these methods, a course was offered using a combination of class and satellite delivery systems. It was hoped this method would cut costs, allow for courses during the year, allow flexibility in instructor selection and provide quality instruction.

2. FORMAT FOR SUBMITTED PAPERS

In 1979, I became responsible for a Higher Education Planning Grant which had been awarded to the Commonwealth of the Northern Marianas. The Northern Marianas, a series of islands located in the Pacific Ocean roughly 1,395 miles Southeast of Japan and 7,500 miles Northwest of Washington, D.C., had recently become a Commonwealth and separated politically from the Trust Territory of the Pacific Islands. In this new status, responsibility for Higher Education had to be considered and the Department of Education had prepared itself to investigate possibilities in conjunction with providing for teacher training. Up until this period of time, training had been provided by sending people away to school and contracting people or universities to offer workshops and courses to students on island. The planning grant study concentrated on higher education which could be made available on the islands.

The study itself has involved investigation into many areas. This paper will concentrate on the aspects involving telecommunication use and a course which was piloted as part of the project. Fortunately, a telecommunications network and station on Saipan already existed which allowed the project to be possible in the first place. The station on Saipan houses equipment and operators for the DISP (Department of the Interior Satellite project) network which has stations in the seven political groups in Micronesia and the PEACESAT network which has stations in seventeen countries in the Pacific. Both use the satellite ATS I and receive allocations of time from NASAU.

I had used the PEACESAT network to take part in discussions with other Pacific Islands and had been impressed with its potential to help offer one alternative to the problems with communication and the need to share concerns in many educational areas. What had surprised me was the hesitancy of people to use the equipment and talk and the minimal use being made by the Northern Marianas for courses and general educational purposes. In a situation where phone connections are undependable and difficult to use if available and not existant between most Pacific Micronesian Islands, it seemed to be an underused educational resource.

One of the first decisions to make in trying to decide how we might use this resource was to pick a course to pilot. I had begun a study with Dr. James Dator from the Political Science Department at the University of Hawaii on the alternative futures of the Northern Marianas. He has a special interest in communications so together we designed a course plan which would supplement the study and pilot the use of satellite for this purpose. We decided, because of the importance of face to face communication in Micronesian cultures, that there should be one week of course work on Saipan to start the course. The following two months would be conducted on a once a week basis by satellite with Dr. James Dator in Hawaii continuing his work there as an instructor at the University. The course would close with a final week on Saipan.

One serious problem in providing courses in the Commonwealth over the years has been finding instructors who are free to offer courses during the academic year. People are most available during the summer but during the year they can usually only come during the Easter or Christmas break, a time when the people in the strongly Catholic community of the Northern Marianas have too many family and church obligations to take courses. When we have tried to fit a course into a few days and long hours, the students do not have time to read materials, write papers and think. This is a particular problem because most students are working in a second language. The course design we worked out seemed to solve the problem of having the instructor we wanted available because he could still maintain his other duties and the students would have time to work on projects with the extended time period.

We decided to offer "Politics of the Future", a graduate level Political Science Course. It fit in with the overall project Dr. Dator was working on and we felt the graduate level would limit the people who would take the course to those who were very familiar with college work. We felt that due to the experimental nature of the project, we did not want to jepordize anyones possibility of sucessfully passing the course. Undergraduate students were admitted by permission of the instructor.

The actual setting up of the satellite time involved first getting an understanding of how the system worked, who was responsible and what procedures needed to be followed. I made a formal request for a weekly time slot to the PEACESAT operator and was given Tuesday afternoons (Saipan time) - Monday evening (Honolulu time). Course permission requests went to the University of Hawaii, registration took place and the course began as scheduled.

Meeting the first week was a mixed group of people. Saipan becomes increasingly each year the home of a multicultural community. Chamorros, Statesiders, and Philippinos took part who were teachers, administrators, a legislative researcher and a Public Affairs Officer. This became an interesting aspect of satellite use. The first week, when the course was taught in a face to face mode, the statesiders tended to dominate the discussion. When the course moved to the satellite station, each person had a time to talk on the microphone and this resulted in all taking part equally. This fact in itself compensated for the lack of face to face contact.

Another favorable aspect of satellite use was the fellowship that developed among the group. We collected each week the assignment and mailed the papers to Dr. Dator. We then discussed the homework papers submitted as one of the first course activities over the satellite. We had a chance to see each others papers and learn from the comments and this lead us to assisting each other as we found information which would help. In addition, we were able to comment among ourselves and not be heard by Dr. Dator and then respond to him. This freedom to comment and discuss without being heard allowed us to agree we didn't understand and let him know or communicate other responses honestly.

We taped each lecture and anyone who missed a lecture was able to listen to the tape. Attendance was generally good but during the process of the course Dr. Dator had to leave Honolulu for Ponape and I had to go to Ponape and the U.S. mainland. These trips gave us a chance to experiment with another aspect of satellite use, that is, being able to take part when in a different location.

One aspect of island life is that you are either on island or off. When you are off island it means you miss activities while you are gone. However, with the course taking part on a satellite with stations all over the Pacific, it gives a freedom to travel and still take part. It also raised the possibility of a wide audience.

Dr. Dator was able to easily conduct the course from Ponape. I was not able to join the course when I was in Ponape because there was an island wide power outage and the satellite station did not have emergency power. When the time for the next class came, I was easily able to phone patch from my hotel room in Portland through the Santa Cruz station and take an active part in the class. I was in Hawaii for the next class meeting and joined Dr. Dator at the station at the University. The following week I resumed taking part in Saipan. The experience was a bit different each time and in all cases benefical. In the past, I had not registered for courses because I knew I would have to travel during the course time. With the use of satellite, this was no longer an issue as to whether or not I took part.

There were negative aspects to satellite use. The transmission was not always clear and sometimes sections had to be repeated, because of the deteriorating orbit pattern of the ATS-1 transmission is at times not possible or is unclear. In addition, more coordination than had been expected was needed on the Saipan end to collect and transmit homework papers and assist students. These matters, however, were minor compared to the benefit of the learning experience.

We had looked into the possibility of visual and paper transmission as an aspect of the course. This would have meant purchasing or leasing equipment. After investigation we realized we would not have enough time alloted to us to transmit via satellite the homework assignments and that Dr. Dator would not have time to review them. Visual transmission did not seem essential to the course although it could be interesting to try if it were available. Voice was the most important aspect. It was also vital that we were able to discuss, question and exchange comments. The mailing of tapes back and forth would not have been sucessful.

The last week of the course Dr. Dator returned and we completed final projects. This proved to be important to the completion of final projects and the pulling together of questions and solutions. The course could have concluded without this final week of meeting but not as sucessfully.

While Dr. Dator was on Saipan he began offering a course through the DISP network for the Trust Territory Justice Improvement Commission. The course was the extension of a one week meeting which had been held in Ponape at the conclusion of which the participants requested additional sessions via satellite. Palau, Yap, Northern Marianas, Truk, and Ponape took part.

The course was sucessfully conducted for four weeks while Dr. Dator was on Saipan. Dr. Dator mailed literature to participants on a weekly basis and these were discussed during the satellite sessions. For the fifth sessions Dr. Dator had to go to Alaska where, because there was no station operator, he was unable to conduct class. He was then in Florda where he patched through Denver and held class with Palau, Ponape and Saipan taking part. The following week only Ponape took part and then the Palau ground station ceased to work properly and could only receive transmission. The Palau participants mailed their comments but this was not a satisfactory method of exchange. A decision was made to discontinue the course.

The combination of these two experiences, one sucessfully completed and one less sucessfully completed leads to the following general conclusions: 1) Equipment must be at least adequate and in working order at all stations involved. At present PEACESAT equipment is not new and needs to be maintained or replaced. The frustrating experience of inability to communicate leads people to give up on the system. 2) Personnel must be available to operate the equipment and supervise its use. 3) There must be a course coordinator on site to follow up, encourage students, assist in transmitting assignments and generally be a contact person for students. Dr. Dator felt this was a particularly vital item to success. 4) The instructor must be able to be flexible and design materials which fit the satellite mode. 5) The course must fill a need felt by all the participants. 6) Initial face to face contact seems to be important in the Pacific Islands. It would be intersting to document this with a control group not having face to face contact. This conclusion is drawn here based on participants comments.

An additional possibility for future courses not experimented with in this course in that experts could be used from across the country for individual classes. These guest lectures could be experts in their field and participate from their home locations via phone patch to the ground station. This type of instruction could enrich the course well beyond the normal course arrangements.

On a final note it must be recognized that this whole project could not have worked without the kindness and expertise of Mr. Esikiel Lippwe the Trust Territory PEACESAT operator and the same patience expertise and kindness of Ms. Carol Misko, University of Hawaii PEACESAT operator. The encourangement and knowledge of Mr. Philip Sosey, Communications Division TTPI and Dr. John W. Bystrom, Director PEACESAT Project made the whole idea workable. The support of CNMI Governor Carlos Camacho and Acting Director of Education Isaac Calvo also allowed for the idea to grow and Dr. Fausto Grado, Director of Continuing Education UOH Permitted the arranging for credit.

Hi-OVIS — New Medium for Future Society of knowledge and Information

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It is expected that that 1980's is the transitional period from the society of the civilization based on materials made from fossile energy to future highly information and knowlege oriented society.

Techonology development will make futher progress. Especially, in the field of information and communication, so-called telematique, which is expected to be the basis for the new future society. Computers will become smaller and smaller in physical size, better and better in cost/performance; the larger amount of information can be transmitted with higher speed; which will make telecommunication cost much lower. The capabilities for storing information, especially video information, will make revolutional progress, which makes video information storage and retrieval much easier.

The above-mentioned technical revolution is further accelerated by the development in such new field as VLSI technology, optical communication technology, satellite communication technology and laser technology.

Next I have to mention that the change of recent industrial structure in Japan.

Japanese industrial structure went through some drastic change since oil crisis. One of the points to be noted in this change is transition towards "service-oriented society", which is another sign of moving towards knowledge and information oriented society.

More than half of the labor force in Japan is engaged in service related business. Also it should be stressed that Japan is rather lagging behind in personal and/or public information services as well as regional information medium.

As the service-oriented society progresses, needs for information system together with its service contents are expected to grow, and becoming more and more diversified and complicated especially in the area of public, personal and regional information services.

There appear to be large needs for new system development in this very field.

Let us draw a rough sketch of the characterestics of service-oriented society.

Service-oriented society can be marked specially in the point that the process of integration, in a broad sence of the words, is going on between the suppliers (producers) and the beneficiaries (consumers) of service.

The distinction between producers and consumers was extremely clear in the former material-oriented society, however, in the service-oriented society, on the contrary, the distinction is vague, which is really the very essence of the service-oriented society.

Even now, for example at banks, customers are required to fill out various forms, tedious paper work,--- without this operation,the whole banking procedure will not be completed.

The same can be said to the government administrative services. When citizens are to receive services, in most of the cases, they are requested to take part in the operation by preparing documents, filling application forms out, etc; otherwise the citizens can not be the beneficiaries of the services.

People who used to have little say in the matter of services against the suppliers or producers are now expected to gain more influence to the system, namely society, as they become one of the integral components of the service procedures in the growing service-oriented society.

Looking at information services from this viewpoint, we must realize that such service as television, the typical information service in the present-day society, which gives only one-sided and passive information to the receivers even though it is massive, will not have a big chance to survive as a form of service in the future service-oriented society.

The users in the information system will want to obtain information they need, at any time and as soon as possible. While playing role of the operators of systems, the users can be information sources at the same time and readily make efforts to improve the systems. This will be the ideal of an information system in the service-oriented society. It should be repeated that such notions as the receiver and the sender of information will become dim in the service system. In order for an ideal system to be designed and developed, the receivers will be required to provide their own efforts and perform the function as data base, besides merely paying money for receive-only information services.

What kind specific development has to be carried out in this country admist the process of transition toward service-oriented society?

One of the possible solutions to the question above will be to carry out new information technology development as well as new service system development based upon the advanced leading edge technologies.

The new service system should be applied to the society actually starting from experimental stage in order to find out social impact such as social needs and people's reaction, in addition to hardware performance evaluation.

By doing so it would become possible to find out the way to develop the practical system being useful for the improvement of human-oriented and service-oriented society as well as having positive influence on the future direction of industry by analyzing collected data, so that we can find out the appropriate course into the future.

This principle has been materialized in the pilot experimental project called Hi-OVIS or Highly Interactive Optical Visual Information System, which of the development was completed July 18, 1978 and has been in operation since then.

Incorporating all advanced information technologies, it is expected that Hi-OVIS helps develop new sprout of industry, and as a new medium, it could create a new market for service industries by preempting the needs for information services foreseen in the aforementioned service-oriented society.

As a result, Hi-OVIS has remarkable features in two fields that could not be found in the conventional system.

First, optical communication technology, which is completely different from conventional electric/electronic communication technology, have been employed in the whole transmission system.

All transmission lines are made of hair thin optical fibers. Theoptical fibers reach in each subscriber's household. The optical fiber made of silicon has remarkable characteristics such as ; low loss of transmission, large transmission capacity per unit sectional area, no inductive interference, resource conservation, low cost etc,.

Secondly, full two-way interactive audio-visual communication function is provided making the best of the above feature of optical fibers. In this system the homes are equipped with keyboards, cameras and microphones in addition to regular television sets.

Besides watching regular TV programs, the subscribers can talk to the center, perform the televote; thus actively participating the programs for themselves. Further, through operation of keyboards, they can obtain necessary information from the data base, located at the center facilities, at any time in various forms such as moving video, still picture, and characters.

Following are the detailed description of these two features.

Regarding the first feature, the adoption of optical communication technologies has been made extensively for the first time in practical application in the world. It has gained highest evaluation from the rest of the world because of its large scale, and moreover, it has given strong stimulation to the reserch and development activities in the area of opto-electronics in the world, leading to remarkable progress in this technology in the past three years. Also several similar Hi-OVIS like development efforts are being planned in many parts of the world.

Further, optical fiber, opto-electro and electro-opto conversion equipments, optical connectors, optical switches, optical junction equipment, optical sensors, holographs and the like lead to "optical parts industries", which in turn are supported by "optical materials industries". Broad-band information networks employing optical communication technologies can be constructed, and many new broad-band information services are going to emerge. A new future industry comprising these new activities is called "optical information industry" including both hardware and software business. This new industry is much expected to grow further to be a new key industry after the electronic industry to support the future of Japan.

Regarding the second feature of full two-way communication, it is a function actualized primarily by the optical technologies and therefore should be discussed in the framework of the abovementioned "optical information industries". Nevertheless, the two-way communication deserved particular attention because, as outlined earlier, it is a logical consequence in the field of information system in the development of service-oriented society, and a also because it is extremely important and interesting, considering the possibility of television, the biggest and strongest visual information system in the present age, turning out to be the biggest failure with its one way communication capability in future service-oriented society.

Television has been diffused thoughout the nation at a remarkable pace over the past 25 years. Television technology has also made great progress at the same time. However, some re-examination is being called for on recognition that television has overwhelming influence and transmits one-sidedly too much information, the high density visual information. In this context the challenging question is what impact Hi-OVIS with full two-way communication capability will have on the future of television. We have been conducting experiments to prove our presumption that Hi-OVIS will find a new possibility of television in the future and has great potential in terms of marketability as well as a great impact on society.

Hi-OVIS, from the standpoint of medium as a community information system, provides life-related information and community information in quite a different way from the conventional one, i.e. by making the best of the broadband transmission lines and full two-way communication capability. The system is expected to contribute to the reconstructions of dying communities as well as to the formation of communities in newly developed towns, as the two-way communication capability enables the subscribers to participate in programs and discussions.

Also, if this kind of community information systems are integrated throughout the country, this will lead to the recognition and identification of a national network in the true sense of the word, whereby the users regard vision as their own and engage themselves in the operation and organization of the systems,as also indicated in the Annan Report of the United Kingdom. This will be a great achivement in the service-oriented society as mentioned earlier.

With many remarkable features and great potential impacts on technological and socio-economical fields in the future, the first model of Hi-OVIS was fully completed on July 18, 1978, in the

Higashi-Ikoma District in Nara Prefecture covering 158 households as its subscribers. Since then, the experimental operation has been continued to the present time. Because the number of subscribers of the systems in limited so far to 158 and because the experiment has been going on for about 2 and half years, it may be too early to draw any conclusion, but the analysis of the results so far obtained reveals:

(1) The optical communication technologies have so far proved to be able to be practically used on the field. Except for initial trivial failures, no essential problems have been found with the optical transmission lines. Despite previous apprehension, the transmission system has shown an extremely high reliability.

(2) The visual information system with the two-way communication capability has a great potential to be established as a new medium. Particularly great significance has been recongnized in the subscribers' participation in community information programs -a genre with great needs.

(3) With the advent of this new medium, community consciousness has been rising in the Higashi-Ikoma District. For example, social gatherings and parties have been held on the initiative of the residents, who have widened their scope of social activities. In this we can catch a glimpse of what the transition to a new service-oriented society will be like. We will also be able to identify the role of Hi-OVIS in community life.

Developing Principles for International Information Networks

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Abstract

The advent of satellites and computers has produced a proliferation of new international information networks; many transmit data only but others combine voice, image, and data in a merged service which accelerates communication across national boundaries. This paper addresses the developing principles which might encourage and rationalize their use to equitably serve global needs.

I. INTRODUCTION

While political arguments increase concerning the right to communication, or to refrain from communicating, international information networks proliferate at a speed which almost challenges that of light to travel. Satellite technology, as it becomes intertwined with computer technology, is revolutionizing and democratizing communications transmission systems by making available real time interactive messages. Space has become irrelevant; time is a matter of zone and convenience. Modes of transmission--either voice, video, text, or data are fast converging to permit transmission of all four simultaneously or separately at the choice or special need of the sender. The cost of both communication and computing is fast diminishing if not vanishing. Satellite technology on a cost per channel basis is going down at 40% per year which is the same rate of decline as the cost of computer storage. Thus, the marriage of computers and communications could permit in a few years' time the universal interconnection of public data networks which will provide maximum flexibility, and optimum diversity, with minimum cost. An integrated global network with access for all is possible.

This paper will discuss the developing principles which might encourage such a global system while permitting separate nation-states to preserve their local and national options. These principles include:

Availability

Reliability

Integrity

Security

Efficiency

Transparency

Interconnectivity

Interactivity

Diversity

Universality

2. PRINCIPLES

2.1 AVAILABILITY

Availability is a matter of physical existence of communications systems. Accessibility has been identified by Japanese scholars to mean "whenever an individual wants to make use of some kind of services he (or she) is able to use them and is guaranteed their use". Availability implies not only the existence of communications facilities but also the actual channel space and operational readiness to receive and transmit messages at a time and place whenever and however there is a message which needs to be transmitted. Today telecommunications facilities are available primarily in the developed world, e.g., developing countries with 70% of the world's population and 20% of the gross national product have only 7.3% of the world's telephones, while 75% of the telephones and television sets are found in only eight countries.

2.2 RELIABILITY

Reliability is a matter of service on a regularly established and uninterrupted basis. Visual telegraphy was not very reliable, because it required individuals to be physically in a position to watch and transmit the signals. Aside from being labor intensive and subject to the usual vagaries of human illness, forgetfulness and neglect, both night and stormy weather brought an abrupt end to message transmission. Smog could be equally troublesome and difficult to control.

2.3 INTEGRITY

Integrity is a matter of message clarity and accuracy. Senders want assurance that the message sent is the message received without error by the intended recipient. Otherwise, business can be disrupted, troops misdirected, and lovers lost.

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Telegraphy was notoriously error prone. Voice telephony and postal text have provided the most satisfactory integrity except in the cases of language incompatability or inaccurate typists, but the systems are more or less distortion free. In computer communications, two computers cooperate to insure that the message is received without error, in its entirety, and receipt is acknowledged by the recipient. In that sense it is superior to the postal service, quite apart from its higher speed and lower cost.

2.4 SECURITY

Security is control of access to messages. Preventing access is desired by some senders but by no means all. Indeed, early telephone operators heard all, visual telegraphers saw all, and young Andrew Carnegie was said to have learned how to succeed as a capitalist entrepreneur from the content of the message traffic he sent as a young telegraph-operator. Yet large sums of money have been spent to encrypt, encode, and scramble messages for military as well as business purposes - the ability to provide security of transmission is of high priority.

2.5 EFFICIENCY

Efficiency is an economic goal that the communications system be cost effective for the purpose intended. Thus, some countries prefer what is called thin route telephony or high powered satellites with low powered ground stations rather than low powered satellites with high powered ground stations.

2.6 TRANSPARENCY

Transparency means that the manner in which a message is sent should not be obvious to the user. Whether it goes by satellite, microwave, cable, or optical fibre should be irrelevant to the user. Neither should the message be distorted or limited by communications systems which are incompatible.

2.7 INTERCONNECTIVITY

Interconnectivity implies more than plug compatability of the technology. It includes protocols for access to, through, and across various public and private networks. If the publics of the nations are to be provided optimum service, then public networks should not be permitted to exclude users of private networks access to the system. The various private networks should be capable of interconnection unless there are compelling reasons for maintaining privacy.

2.8 INTERACTIVITY

Interactivity implies the potential for immediate response in real time as on a voice curcuit telephone system or face to face conversation. Such interactive communication is becoming more readily available in the mass media as well as in the point to point systems. Television teleconferencing takes place every weekday night on the McNeil/Lehrer Report on U. S. public television.

2.9 DIVERSITY

Diversity dictates the existence of choice of a variety of modes of transmission, e.g., telegraphy, telephone, telex, facsimile, cable, television, etcetera. User choice rather than carrier choice or regulatory ruling should be the prevailing principle. The sender should be able to use voice, video, text, freeze frame, graphic or data transmission singly or in combination according to the nature of the function. Use should not be limited by legal restrictions which inhibit technological development. In the United States, the Federal Communications Commission has recently acted to remove the unnatural legal barrier between computers and communications thus freeing technological development to pursue whatever the marketplace dictates in terms of consumer choice, economic viability, and message need.

2.10 UNIVERSALITY

Universality is, of course, the ultimate extrapolation of availability and interconnection and transparency. Universal availability of some modes of transmission has been achieved in several of the more developed nations; but only in Japan do some of the policy analysts claim to have reached a saturation point of information delivery in 1965 with only 75% of the households with television and 40% with telephones. Even some Japanese scholars claim that a saturation point can never be reached because the appetite for information increases exponentially with the availability of new communications technologies. Thus, the United States sees no saturation point in sight with 95% of its households with telephone service and 98% with television, because home computer terminals present an entirely different mode of message transmission and delivery and use. In the use of video players Japan has already more than doubled the United States performance.

3. EXISTING NETWORKS

In order to demonstrate these developing principles, it is instructive to review satellite systems and data networks which illustrate the principles proposed.

3.1 INTERNATIONAL COMMON CARRIER

We now have a global satellite system. The international satellite system known as INTELSAT is providing common carrier service to 130 nations with 60% of the international messages traveling via its transponders. The primary use is telephone traffic. The vast majority of participating countries are developing nations. The existence of this global system has revolutionized world communications paths. Underwater sea cables heretofore interconnected only the most developed countries of the world. Such cables are not going out of existence. Indeed, they are proliferating because they provide reliability, redundancy, and security of transmission. INTELSAT, however, is a multipoint rather than point to point service which by its very nature provides more equitable access. It is distance insensitive, and volume insensitive, so small users are not penalized by higher rates. Thus, there is no inherent advantage of large and powerful nation users over the smaller and economically less developed. Each country can and does maintain its national autonomy and controls its own interconnection to the global system. The primary change is general availability to all nations that wish to participate. INTERSPUTNIK provides a similar common carrier service for the Eastern European countries.

3.2 NAVIGATIONAL SATELLITES

The navigational satellite system established last year, INMARSAT, will provide accurate location to all ships at sea anywhere on the globe. The precision of such navigational aids is phenomenal. The United States Navy's NAVSAT satellite has a global positioning system (GPS) which is accurate to an average error of less than ten meters which is sufficient for almost every conceivable purpose. Thus, international maritime transportation will be facilitated by savings in time as well as a high degree of safety for crew and cargo. The development of a more integrated and interdependent world economy is likely to be accelerated unless political considerations dictate other courses of action.

3.3 MILITARY NETWORKS

While INTELSAT provides a public global common carrier service with access controlled at the national level, special purpose satellites and satellite systems are proliferating. The military satellites for surveillance and communications provided a primary motivation for the research and development which led to space communication. Although not controlled on an international basis, they do provide the necessary information to maintain peace. Furthermore, they could be administered on a global basis to provide the surveillance to insure that arms control agreements are to be honored. The United States worldwide defense communications system is so sophisticated that those with access to it become frustrated when encountering the interruptions, delays, and distortions inherent in more primitive land based wire and radio transmission systems. Land lines in central Africa, for example, suffer from giraffes knocking the telephone wires down, baboons eating the insulation, and Nomads cutting the wires down to tether their goats.

3.4 WEATHER SATELLITE

The weather satellite, NIMBUS, operated by NOAA, is probably next in significance and sophistication. The morning television news has been altered radically by real time satellite pictures. Computer graphics analyze on our television monitors rain clouds or sunshine, so we can plan our day accordingly. There is no inherent reason other than cost why these weather pictures should not be available worldwide via satellite directly to any saucer anywhere on the globe.

3.5 GEOLOGICAL MONITORING

LANDSAT, a NASA-operated satellite, provides remote sensing of earth surface conditions, identifies sea bed resources and assesses the geological wealth of nations. Although owned and operated by the United States, the information is disseminated widely to other nations. Heretofore unknown facts have revealed interesting information such as the news that current maps plot a Bolivian river seven miles off course. Remote sensing can provide more information about a country than it knows or even wants to know about itself. However, thorny political and economic questions have arisen from the use of this information. Who has access to the flow of information which is readily sought? Who controls the outflow of information which has economic value? Can or should a country be able to prohibit the remote sensing of its surface? Technologically, such control cannot be exercised without violent, destructive, and prohibitively expensive means. Practically, access can be encumbered by political and legal protocols which protect economic investment.

3.6 BUSINESS SYSTEMS

The business uses of global satellite systems are also proliferating. Most of these are developing by private leased line facilities in the United States. In Europe and elsewhere PTT's and responsible government officials are moving to provide public data networks for both public and private sector use. Two of the functional international systems which have received the greatest exposure and use are the banking system known as SWIFT (Society for Worldwide International Funds Transfer) and SITA (Societe Internationale de Telecommunications Aeronautiques).

The banking network has revolutionized international banking practices by reducing the international monetary market to on-line, real-time, twenty-four hour banking practices, because money is in constant motion around the globe. With instantaneous communication to everywhere, this has led to the disruption of sleeping habits of international bankers who must keep track of the changing fluctuations in yen, dollars, marks, pounds, pesos, and rubles.

3.7 TRANSPORTATION NETWORKS

The airline reservation system knows no national boundaries, nor even political animosities. Although most nations maintain a national airline to enhance their prestige if not their pocketbooks, the proclivity to national identity of transportation systems has not yet spilled over to international digital communications. For example, Balkan (Bulgarian) Airlines, Malev (Hungarian) and LOT (Polish) Airlines process their reservations through a large CPU installed in Atlanta, Georgia.

3.8 CABLE AND TELEVISION

Entertainment and informational uses of satellite systems are proliferating but primarily through the use of domestic satellites. In the United States, the RCA and Western Union satellites are being used extensively to diversify television programming to a wider variety of uses: religious, pay TV, foreign language; and to a broader spectrum of purposes: teleconferencing, teletext, facsimile, and remote editing.

The global impact of such instantaneous, worldwide distribution of television signals was most dramatically demonstrated during the moon landing of July 20, 1969. Transmitting pictures for twenty two hours of uninterrupted coverage required the cooperation and teamwork from some four countries and one interstellar body; the picture was transmitted from the surface of the moon to the space tracking station in the Red Center of Australia, then via INTELSAT to Jamesburg, California, by NASA radio relay to Houston, Texas, from there via an Atlantic satellite to Goonhilly Downs in the United Kingdom from there via the Eurovision network to participating national networks. Thus, all citizens with access to the international network were privileged to watch when the first human, astronaut Neil Armstrong, stepped out of the spacecraft, Eagle, and planted his 9 1/2B lunar boot on the moon. An audience of 538 million was estimated to be watching. A truly global audience.

3.9 EDUCATIONAL USES

Educational uses of satellite systems are still in a more primitive stage of development, although the uses are quite sophisticated. Control Data's PLATO system provides hundreds of educational software programs worldwide of CDC's CYBERNET system which reaches twenty-four nations. The use of these educational programs is limited more by the cost than by the availability. Anywhere a customer exists with access to a telephone and satellite uplink, the technology provides access to on-line, instantaneous, individual, computer assisted learning.

The PEACESAT network in the South Pacific is perhaps the most extensive use of satellites in a widely dispersed area of South Pacific islands separated by large bodies of intervening water. The Indian SITE experiment and the Canadian CTS and United States ATS 3 and 6 satellites successfully demonstrated educational and medical uses of communications in remote villages in India, Alaska, and the northern territories of Canada. Yet none of these has achieved normal operational status.

3.10 PRIVATE NETWORKS

Multinational companies are developing their own internal private leased facilities. IBM, for example, has several world wide data networks, the earliest of which was called the SUN network, because the sun never sets on it. With the technology proposed by the Satellite Business Systems internally within the United States, which supports voice, video, and text all in a digitally encoded time division multiplexed access (TDMA) system, such multinational businesses could be provided with private company managed communications systems. These could technically, if permitted, bypass the PTT's. Such private intracompany communications technically offer great flexibility, diversity, and interactivity. What they do not offer is interconnection unless they are required by law to interface with public switched networks or vice versa.

4. SUMMARY

Interconnectivity is of high priority if new satellites systems are to be used most productively. Investment in existing terrestrial and mobile systems far exceeds the investment in computerized communication. Efficiency also dictates optimum use of existing facilities. Transparency must be achieved if the use of such interconnected systems is to be cost effective. Thus, interactivity is also necessary, especially if individuals are to have the benefits of consumer choice in the new individualized educational environment provided by such systems as PLATO.

To reiterate. Those who seek a truly global communications system which provides user options for both nation-state and individual users should support the following principles for a global communications system:

Availability

Reliability

Integrity

Security

Efficiency

Transparency

Interconnectivity

Interactivity

Diversity

Universality

It is my prediction that the technology is developing so fast and the users adapting so easily that the politicians and diplomats will still be arguing and negotiating about prior consent and balanced flow long after the above ten principles have already been achieved.

New FDM Terminal Equipment With Automatic Maintenance System.

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A new FDM channel translating equipment in series N5000/S has been developed, accommodating 240 channel modems in a MR-2 equipment frame 2750 mm (H), 120 mm (W) and 225 mm (D) which can be mounted 1200 channel modems in a conventional floor space (600 mm (W), 225 mm (D)).
To realize low cost, low power consumption, size reduction, easy installation, easy operation and simple maintenance, newly developed components and circuit technologies were adopted. The miniturized pole-type torsional electromechanical filter and integrated circuit have been specifically developed for the new channel modems. Based on the same considerations, group, supergroup, mastergroup, supermastergroup, 15 supergroup assembly translating equipment and their associated equipment for up to 18 MHz (3600 channels) multiplex system have been also provided in the same series.
Saving time-consuming routine maintenance of the system, a built-in type automatic supervisory facilities with micro-processor is provided to measure and indicate the individual condition of carrier levels, pilot levels and other alarm informations.

1. INTRODUCTION

Transition from Vacuum-tube type to transisterized Frequency Division Multiplex Equipment (FDM MUX) began in the latter half 1950s, followed by the successive developments of new types of FDM MUX aiming at further high quality, miniaturization of components, and low power consumption to cope with the continuing technical innovation, advancing circuit design technology, and the multifarious social service demands.

Under such technological environments, the N5000 series FDM MUX of new Equipment Practice called "MODURACK", abbreviated as MR-1, and the N5000/s series FDM MUX of MR-2 has been developed to respond to an intense and growing need for reliability. Both MR-1 and MR-2 are based on our extensive research, experimentation, and experience gained through the development of our conventional B1 through B6 (BOOK type) MUX series.

In recollecting success with size reduction, it is perhaps natural and attractive for those interested in "Equipment Practice" to think of notably Channel Translating Equipment (CH TR).

New N5000/s series CH TR is about 1/5 that for conventional B6 series CH TR --- a revolutional size reduction.

It is of great interest to recollect the history of development of various kinds of CH TR.

Fig. 1 is a plot of number of channel ends per conventional bayside against marketed years of the CH TRs.

It is evident that size reduction achieved by the newest N5000/s series CH TR mounting 1200 channel ends agrees quite well with the anticipated dash line.

Size reduction has also been achieved with N5000/s series FDM MUXs of higher stages, scoring technical benefits for the users such as floor space savings, and low investment and maintenance costs.

2. SYSTEM FEATURES

(a) Compactness

Former LC type CH TR had 240 channel modems accommodating capacity per bay, 2750 mm(H) by 520 mm(W) by 225 mm(D). The capacity has been improved to 1200 channel modems per 600 mm(W), or almost five times reduction in size. The entire volume of 3600 channel system is less than 2 cubic meters (2750 mm(H), 3000 mm(W), 225 mm(D)). This amazing compactness is attained by the adoption of miniaturized EM filters, integrated circuit, and other small passive components.

(b) Automatic Supervision

Plug-in, built-in type Supervisory system using an 8-bit microprocessor can be incorporated in FDM MUX. A compact thermal dot printer can be also plugged in. These facilities permit pilot and carrier levels of each equipment to be automatically checked, thereby contracting drastically the time-consuming routine maintenance effort.

(c) Flexibility

A minimum functional unit is modurack (MR). Any MR has a height of an integral multiple of 112.5 mm(H). Intra-bay bus cable is equipped with connector assemblies having the same pitch. Since the bus cable contains all wires between MRs which are power, alarm and all kinds of carriers, each MR can be mounted free in order at an arbitrary position of the frame. This flexible construction permits system configuration that can best satisfies the customer need from low to high density capacities. Interface conditions can meet levels of a wide range by use of continuous and step type variable attenuators. The system can operate from eigher one of three kinds of input power DC -48/-60V, DC -24V, and AC 100 to 140V/190 to 240V.

(d) Improvement of Transmission Quality

Performances of all N5000/s series moduracks are designed to meet or surpass the latest CCITT recommendations --for example (CH-TR):

Low noise:	Less than 100 pWOp
Low group delay distortion:	CCITT Rec.G.232C (Equivalent to LC type CH TR)
Small passband ripples:	Less than 1/10 CCITT
Carrier leak	
within the frequency band of 60 to 108 kHz:	Less than -35 dBm0
outside the frequency band of 60 to 108 kHz:	Less than -50 dBm0

(e) High Reliability

Conventional mercury relays with mechanical contacts in CH TR signal receive circuit have been superseded by transistor relays, resulting in an improvement of MTBF of total signaling system. Printed circuit board patterns have been greatly simplified due to Custom made ICs. All carrier supplies and power supplies are capable of redundant operation.

(f) Simple Installation

Equipment frame is made of and aluminum alloy and weights less than 20 kg. One-man installation is available. Connection to intra-station cables are all connectorized and system is established by merely inserting each MR in a predetermind location. Intra-station cables might be prefabricated with connectors before introducting into bay frame.

(g) Low Power Consumption

Per channel bank (one basic group) power consumption is less than 3.5 watts. To conserve power, modulators and demodulators are series connected and numerous C-MOS type ICs are used.

Fig. 2 illustrates 60CH to 3600CH SYS configuration.

Fig. 3 indicates main equipment performance data.

3. TRANSLATING EQUIPMENT

3.1 Channel Translating Section

The channel translating section has a function for multiplexing 12 voice channels in the 0.3 to 3.4 kHz band for allocating in the 60 to 108 kHz basic group B. The voice frequency signals are first translated into the signals of 128.3 to 131.4 kHz carrier band by the 128 kHz premodulation carrier, and then grouped into a basic group by 12 channel carriers spaced at 4 kHz in the 192 to 236 kHz band. A signaling frequency equivalent to 3.825 kHz is then coupled to the premodulation band at 131.825 kHz. The group pilot remains at the 84.08 kHz or 104.08 kHz frequency. Accordingly, the Channel Translating Modurack has the following features:

(a) A floor space, 600 mm(W) by 225 mm(D), can accommodate as many as 1200 modems.

(b) Group pilot is supervised by an Automatic Level Monitor Controlled by an 8-bit microprocessor. To accommodate the optional automatic level supervisory system an address circuit is provided on the Group unit.

(c) Adoption of monolighic IC increases reliability by eliminating many individual components. The signaling relay of the receiving path uses high breakdown voltage transistors.

(d) Wire-cutting type variable attenuators are used for level adjustment of voice lines, eliminating the need for soldering and expediting job-site installation work.

(e) Torsional mode, 128 kHz premodulation frequency, attenuation pole type EM CH filters achieve low group delay distortion equivalent to LC-type filters. Can be used for multi-link data transmission. Since the realization of the pole type EM CH filters by adopting circuit, design, automation, and material technology, they have been mass produced in the automated manufacturing line. The EM CH filter adopts the parallel-ladder type attenuation pole construction to achieve the optimal, assymmetrical attenuation characteristics.

Extremely stable overall characteristics of the CH filter are obtained by reducing element sensitivity of LC parallel tuning circuit annexed to each of input and output ends as to passband and applying a novel temperature compensation method in the design of transducers and external tuning circuits. A mechanical coupling method is used for parallel connection of the CH filter, thereby reducing the number of transducers by one. Fig. 5 illustrates a mechanical vibration mode composed of a channel filter and a signaling filter. The manufacturing line has been unified and simplified by the adoption of electromechanical wave separation techniques and the standardization of transducer structures for channel and signaling filters. All processing stages for materials, transducers, resonators, and filter assembly are automated. Fig. 4 shows CH and signaling filters. Fig. 6, 7 show typical characteristics of these filters.
Temperature characteristics are extremely stable over 0 to 65°C.

3.2 Higher-order translating Section

The group translating section has a function for multiplexing five groups of 60 to 108 kHz band (CCITT basic group B) for allocating in the 312 to 552 kHz basic supergroup.
The supergroup translating section has a function for multiplexing either 1, 2, 5 or 16 supergroups of 312 to 552 kHz band (basic supergroup).
15 Supergroup Assembly Translating (15 SA TR) equipment has the function of translating 312 to 4028 kHz band basic 15 SA to any one of 1800 channel (312 to 8120 kHz), 2700 channel (312 to 12336 kHz), 3600 channel (312 to 16900 kHz, under studying by CCITT) systems. A 411.92 kHz or 547.92 kHz supergroup pilot with send level of -20 dBm0 (G-TR), 60 kHz or 308 kHz pilot with le level of -10 dBm0 (SG-TR) and 300 or 308 kHz pilot at -10 dBm0 level (15 SA-TR) can be injected into the send side circuit. On the receive side automatic gain regulation or pilot monitoring using the pilot can be provided, if required.
Each Translating Modurack has the following features.

(a) ICs, open-type LC filters, thick-film hybrid ICs, small transformers, etc. are combined for structural compactness. The capacity of each translating equipment measuring 2750 mm(H), 120 mm(W) and 225 mm(D) is as follows.
G-TR: 10 group modems with AGR, SG-TR: 16 SG with AGR (16×2 SG without AGR), 15 SA-TR: two 3600 channel systems.

(b) Optimum unwanted sideband suppressing facilities achieved by the monolithic modulator have lowered considerably the attenuation rating requirements for the bandpass filter. Furthermore, the latest filter design technique utilizing CAD has succeeded in reducing the number of coils in the filter structure.

(c) Automatic gain regulation is realized by FETs as variable resistance elements to determine the gain of the monolothic IC active demodulator.
A memory circuit can be optionally added to the AGR circuit. The circuit memorizes the level just prior to the occurrence of a trouble in case of line failuire, thereby contributing to line level stabilization.

(d) Input and output levels each are continuously variable, enabling rapid and accurate level adjustments under service-in status.

(e) Thick-film hybrid ICs are used for modem and FET peripheral circuits.

(f) Each supergroup carrier frequency needed in the translation is generated by VCXO in the supergroup modem unit upon receipt of fundamental frequency. Consequently, the carrier supply circuit is simple and equipment reliability is improved. Incidentally the VCXO is realized by a thick-film hybrid IC.

4. CARRIER SUPPLY EQUIPMENT

The fundamental frequency, carriers, pilot frequency, and signaling current needed for each translating section are generated by and fed from the Master Oscillator MR, Channel Carrier Supply MR, Group Carrier Supply MR, Supergroup Carrier Supply MR, and Wide-band Carrier Supply MR. Functions and feature of this system include:

(a) The system can be operated either unduplicated or duplicated. In the duplicated system, should a malfunction occur in the carriers or the pilot, an individual faulty unit is switched to the stand-by side and alarm information is displayed at the front of the unit. The master oscillator section alone can be duplicated, if required.

(b) Automatic frequency control facilities can be annexed in the Master Oscillator MR, if required.

(c) In the 60/120 channel systems, the Supergroup Carrier Supply MR can be dispensed with. Thus, the Group Carrier Supply MR is designed to facilitate, if required, inclusion of 12 kHz for SG1 carrier and 60 kHz line pilot generating and supply circuits.

(d) Supply Capacities

CH CS MR:	100 banks of CH1 to 12 modems, maximum
G CS MR:	50 banks of G1 to 5 modems, maximum
SG CS MR:	2 banks of SG1 to 16 modems, maximum

WB CS MR: 2 banks of 15SA1 to 4 modems, maximum

(e) In the channel & group carrier supply MRs, stabilized higher harmonic waves are generated by logic circuits instead of saturation coils which were used in the past.

(f) For the stabilization of the output level of each channel and group carrier, limiter circuits composed of ICs are adopted for simplification and stabilization of circuitry.

(g) Group and supergroup pilots are generated by separate crystal oscillators. The output level is highly stabilized by the AGC circuit composed of ICs.

(h) Main digital circuits employ C-MOS ICs for low power consumption.

5. BUILT-IN SUPERVISORY EQUIPMENT

This supervisory equipment is primarily designed and produced for the purpose of performing quickly without error routine maintenance which used to be done manually. The equipment automatically monitors lines in the station. More specifically, it scans and measures the carrier levels and pilot levels, and prints out and displays the measured value. It also enables the measurement of an arbitrary test point by pushbutton operation.

The supervisory equipment is compact enough to be built in an FDM MUX frame with the result that no extra floor space is needed for a control unit and peripheral devices. This equipment is built up with an Automatic Level Monitor MR (AUTO LEV MON) governing the measurement procedure for all test points and the control of the display section and a printer, a Level Detector MR (LEV DET) which can send address signals to each test point, convert the input information (an analog signal) to the DC signal (A-D conversion), and set and control the switch at each test point, and a printer MR (PRT) which prints out the result of measurement.

In order to meet the tendency of increasing test points, frames are designed to mount a maximum of 9 LEV DET MRs per system. An address bus line (8 bits) for designation of the address of a test point and a signal BUS line for carrying measuring signals run between measured MRs and a LEV DET MR. An AUTO LEV MON MR is interfaced with a LEV DET MR by the signaling lines as specified by the CCITT Recommendation V-11. Data are transferred by polling system between the AUTO LEV MON and LEV DET at the bit rate of 1200 bps. When the LEV DET sends the address signal of a test point to the 8-bit address bus line as directed by the measurement command, the contact of the output relay of the monitor signal closes at the test point of a selected MR, and the monitor signal is sent out to the signal bus line through the closed contact. The LEV DET selects and amplifies this monitor signal, and transfers it to the AUTO LEV MON after A-D conversion. In automatic scanning measurement, the LEV DET scans and measures the test points one by one. The measured data sent from the LEV DET are indicated by the LED character display and printed on a printer as classified by the test point number, measuring equipment name, kind of the signal applied to the test point, and the value of a measured level. For carrier supply MRs, classification of normal/stand-by is indecated and printed. Each LEV MON has a capability of measuring as many as 254 test points. That is, one LEV MON can measure 5 slim frames.

Measurement is made at the speed of 1 sec/point. Data within the range of the basic 5 dB level can be indicated and printed in increments of 0.1 dB. Both AUTO LEV MON and LEV DET incorporate an 8-bit microprocessor and all processing procedures are memorized in the PROM. When the FDM MUX is increased or modified, test points can be easily changed by setting dip switches in the LEV DET. No change is required to either hardware or software. This feature permits the system design full of flexibility. Various kinds of LEV DETs are developed for various FDM systems, resulting in application of the LEV DET over a wide range of systems. As mentioned above, by adding only one circuit to decode the data carried on the address BUS line and one relay circuit to be connected to the signal bus line at the test point of each MR, and providing simple intra-frame BUS line wiring, this system enables automatic level measurement of various PILs and CARs of the FDM MUX. Moreover this automatic supervisory system offers a compact and economical system which can easily meet the extension and modification of the FDM MUX.

6. MECHANICAL DESIGN

The external dimensions of the frame measures 2750 mm(H) × 120 mm(W) × 225 mm(D), which is more slim than conventional frames. Main members of the frame are made of aluminum alloy which is lightweight and sturdy. On the right side of the frame runs an alarm and carrier bus cable covering bands from channel to supergroup. Electrical connection is established through MRs and connectors. When the frame is erected, its top is fixed by two bolts and the pin projected from its bottom is fitted into an aperture in the steel base. Therefore level adjustment is not needed when the frame is erected. Thus the erection and installation of the frame can be done by one man.

When leading station cables into the frame, first connect connectors at cable tips. For the connection of the connector to the station cable, the wire wrapping method is applied to a pair cable, and the clamping method to a coaxial cable. Station cables with connectors are led through the cable duct located at the rear of the frame. Then the pair cables are fixed to the post on the left side of the frame or coaxial connectors are snap-in-connected to terminals at the upper side of the MR. All MRs are plugged in bus cable and station cable connectors when mounted on the frame. Therefore no special tools nor guide plates are needed for modurack mounting.

As the heights of all moduracks measure in integral multiples of the basic height (1H = 112.5 mm), a MR of any height can be mounted at an arbitrary position of the frame resulting in extremely flexible system configuration including extension and relocation of the MR. Between adjacent frames, power, alarm, and carrier bus cables can be connector-plugged-in at the front of frames.

All necessary works for the installation of the frame can be done easily by one man at the front of the frame. Also the frame is compact and light enough for a man to carry into a building. These features will greatly shorten the installation time and bring about highly reliable connection. Prewiring at the plant for the connection of station cables with connectors will further shorten the installation time and improve connection reliability.

7. ACKNOWLEDGMENT

The authors would like to acknowledge the guidance and encouragement of MR. T. Yamada and MR. H. Yuuki in the Transmission Division, MR. M. Watanabe and MR. Y. Kuzushima in the Overseas Transmission Division, and many other people who contributed on this project.

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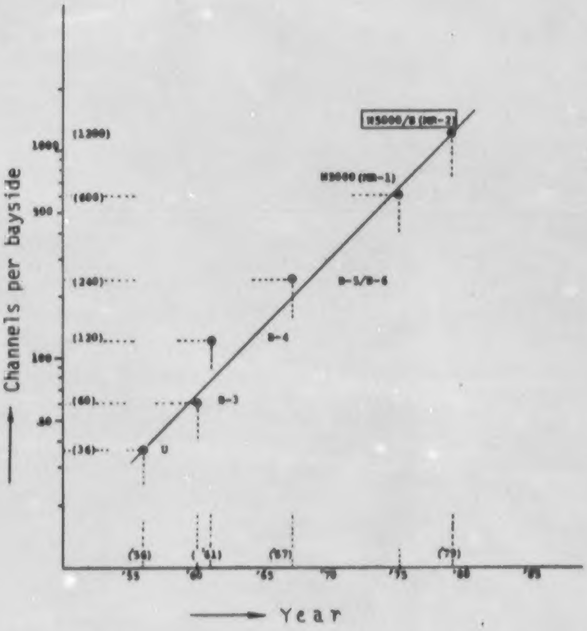


The number of channel ends per bay side (conventional bay) of the channel translating equipment of NEC's carrier telephone system, plotted against the years in which they were marketted

Fig. 1 The Trend of Size Reduction (Channel Trapslating Equipment)

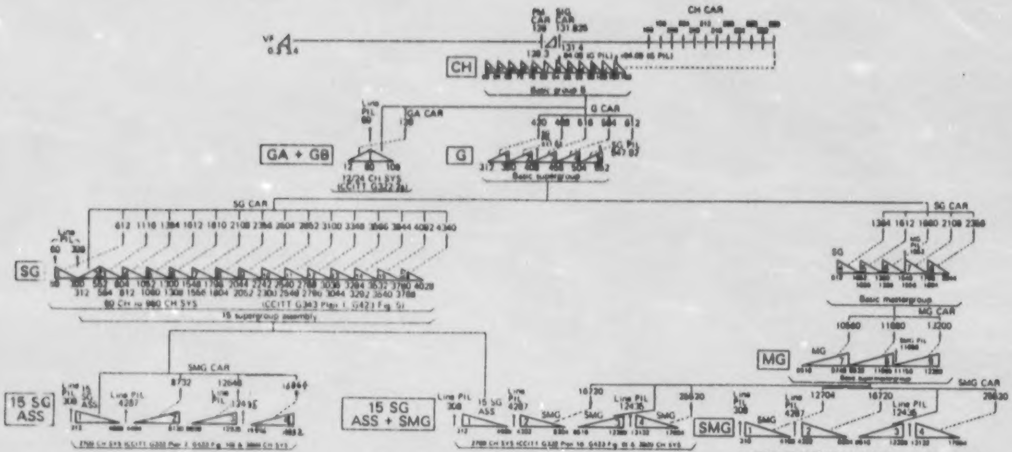

CH CAR
CH
Basic group B
GA + GB
GA CAR
G CAR
G
Basic supergroup
SG CAR
SG
15 supergroup assembly
MG CAR
MG
Basic mastergroup
SMG CAR
15 SG ASS
15 SG ASS + SMG
SMG

Fig. 2 Frequency Allocation

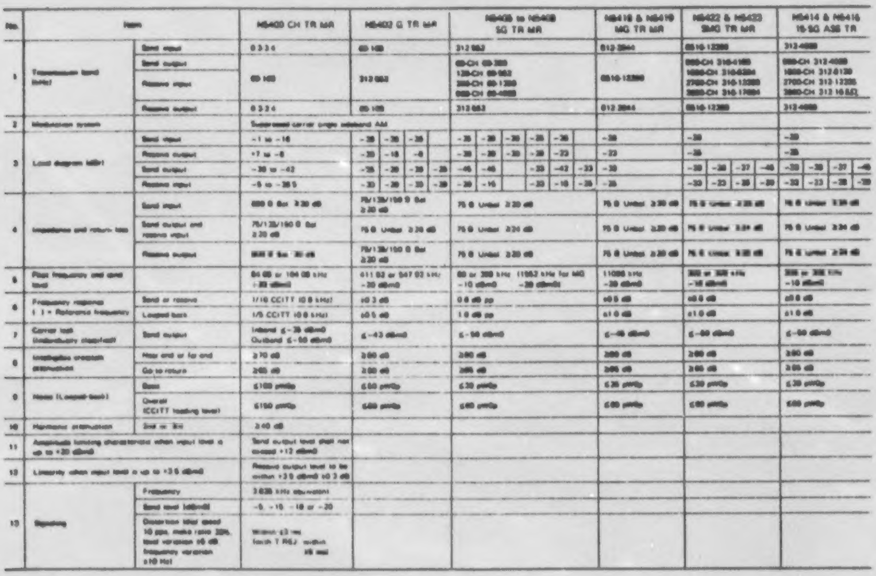


Fig. 3 Translating Equipment Performance Objectives

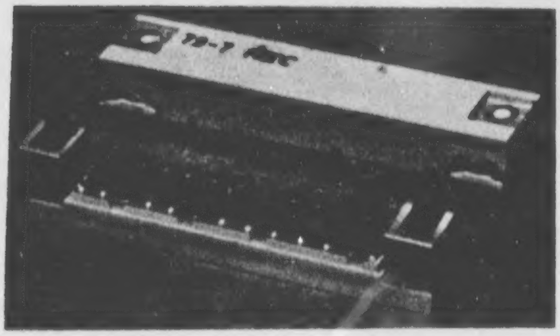


Fig. 4 Electro-mechanical Filter

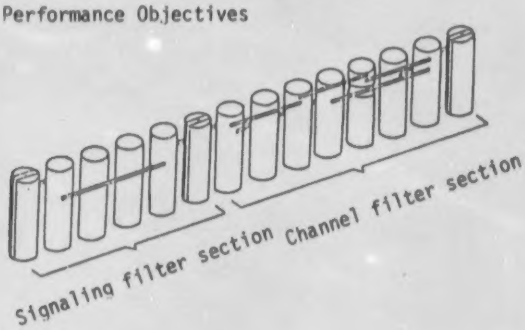

Signaling filter section
Channel filter section

Fig. 5 Mechanical Channel and Signaling Filter with Torsional Resonators

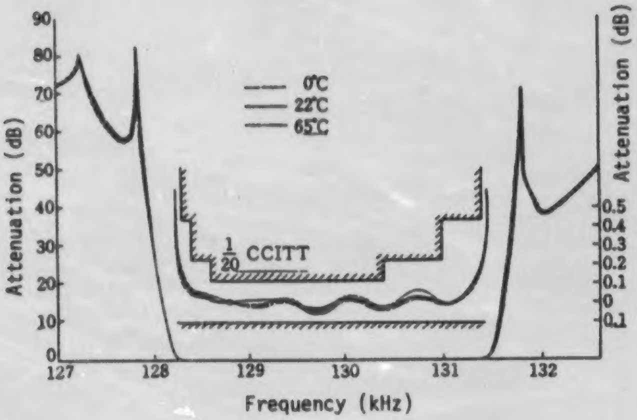


Fig. 6 Attenuation Characteristic of Channel Filter

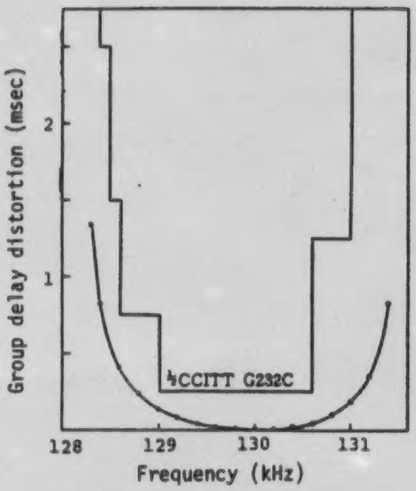


Fig. 7 Group Delay Characteristic of Channel Filter

Fig. 8 Channel Translating Equipment with 1,200 Channel Modems

Fig. 9 3,600-Channel System

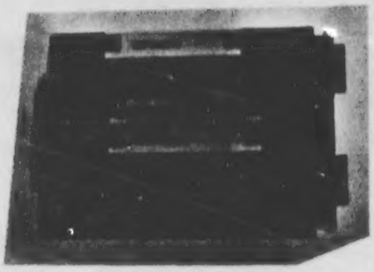
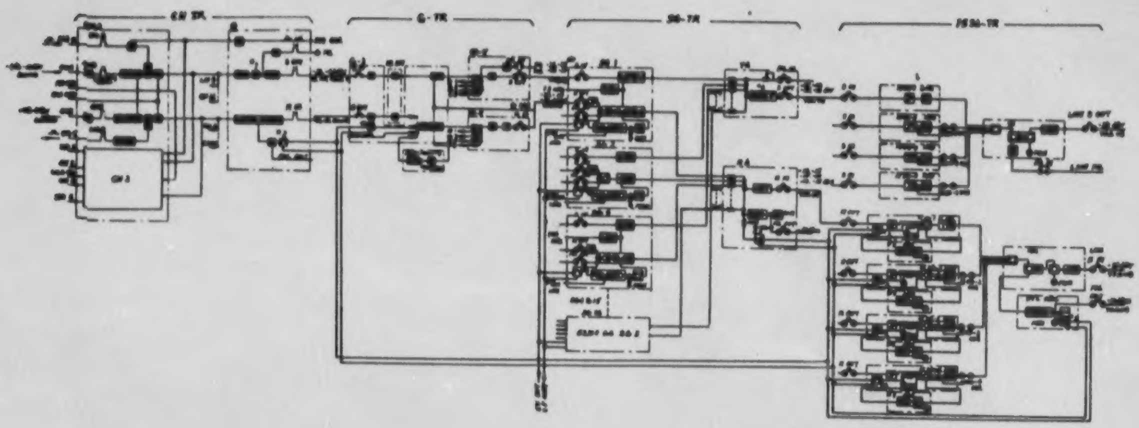


Fig. 10 Channel Modem Unit (2 Channels per Unit)

Fig. 11 Channel Translating Block



NOTE: *1 84.08 or 104.08 kHz Rejection Filter (Option)
*2 Switch for Centralized Supervision (Option)
*3 PIL MON is replaced by G AGR
*4 1552 kHz Rejection Filter (Option)

Fig. 12 System Block Diagram (Translating Part)

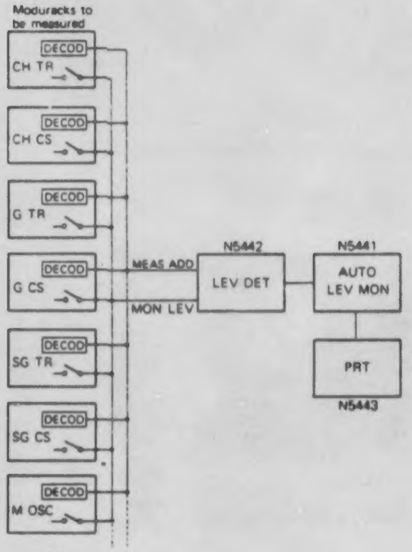
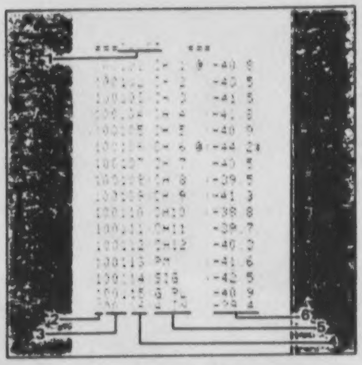

Moduracks to be measured
DECOD
CH TR
DECOD
CH CS
DECOD
G TR
DECOD
G CS
DECOD
SG TR
DECOD
SG CS
DECOD
M OSC
MEAS ADD
MON LEV
N5442
LEV DET
N5441
AUTO LEV MON
PRT
N5443

Fig. 13 Automatic Supervisory System



NOTE: 1. Modurack name
2. Bay number
3. Modurack number
4. Measurement point number
5. Measurement item
6. Measurement level (dBm)

Fig. 14 A Sample of Printer Output

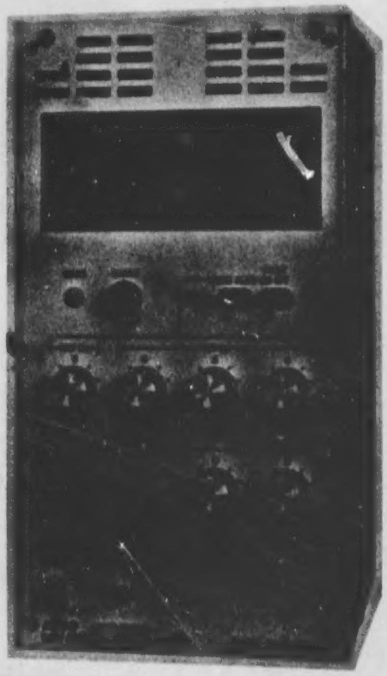


Fig. 15 Automatic Level Monitor Modurack

An Improved Echo Canceller
Designed For New Zealand Conditions

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Abstract

In cooperation with the New Zealand Post Office a telephone echo canceller has been designed which differs markedly from the conventional correlative canceller. When the call is initiated a pseudorandom binary sequence is transmitted along the channel for 0.1 second. It sounds like a subdued scratch and it does not interfere with normal conversation. Correlation of this sequence provides all of the constants for the transversal filter needed to cancel echoes. Theoretical predictions, backed up by bench testing show echo cancellation to at least -36 decibels.

1. INTRODUCTION

Local telephone connections are made on bidirectional pairs of wires called "2-wire" circuits. Calls over greater distances are made by means of unidirectional "send" and "receive" paths. These are called "4-wire" circuits. It is the interface between the 2-wire and 4-wire circuits, called hybrid transformers, where most echoes originate. Characteristics of this interface is discussed extensively by Weinstein [1] and does not need further elaboration here.

Although echoes have always been present on local and national circuits, echo itself is not a problem as long as the delay to the echo is short. Delayed echoes were already a problem in such countries as the U.S. and Australia, prior to the extensive use of international circuits. Echo suppressors, the detection of conversational direction and inserting a fixed loss in the return path, have been used extensively in the U.S. but without altogether satisfactory results, as discussed by Weinstein. When used in satellite circuits, echo suppressors were even less effective, as reported by Rosenberger and Thomas [2].

Figure 1 shows how quickly the transmission quality is degraded by delay in the echo [3]. Where a satellite link is used, delays in excess of 500 mS makes delay interference extremely serious. It is interesting to note that echo cancellers are designed for the national network, with one echo canceller at each end of the circuit on international calls, hence the canceller does not need to be designed for 500 mS delay. Also, say on a call from San Francisco to Auckland, an echo generated in New Zealand would annoy the San Francisco caller, whereas an echo in the U.S. network would annoy the Auckland caller.

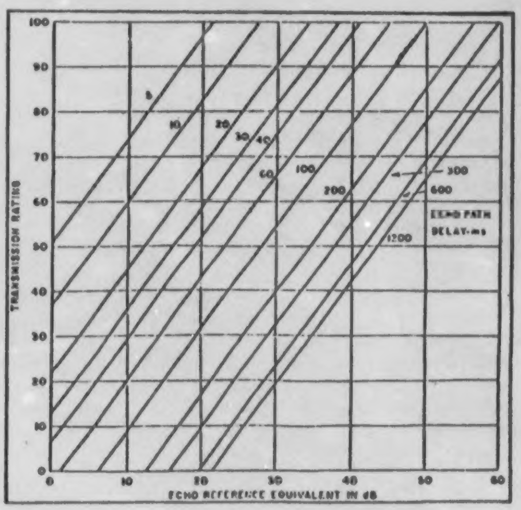


Figure 1. Transmission rating versus echo path delay (Reproduced from [3]).

There are very significant differences in the various designs of echo cancellers [4,5,6,7]. Many of the results of echo canceller performances have been reported by COMSAT [8]. Typical results show 21 dB to 25 dB of echo cancellation, which is quite satisfactory for most purposes. Some newer designs show even better performance.

All echo cancellers use transversal filters for achieving cancellation, and almost all use correlative learning to measure the constants for the transversal filters. Although this is a generally satisfactory method, correlative learning is also subject to "double-talk" problems (both speakers talking at the same time), in that it uses speech as the basis for learning. Learning can be achieved only while speech is present on the line, and this procedure is sometimes slow. To protect the echo canceller from measuring erroneous filter constants in cases of double-talking, a double-talking detector is frequently used to switch off the canceller.

A comprehensive study of echo characteristics was reported by CCITT in 1975 [9]. These tests were carried out on the French telephone network, but the results are believed to be fairly generally applicable, although total delay in the response will be a function of the size of the country. These tests showed a mean echo transfer attenuation of 13.6 dB, with a standard deviation of 5.1 dB.

If an impulse function is placed on the line, there follows a period of fixed delay and finally an active period of the response. Tests showed that the active period, containing greater than 99.95% of the impulse reflected energy, is confined to an 8 mS period. Time delay to the active period will vary considerably, but in New Zealand it is not expected to exceed 20 mS. Another report shows that the peak of the response will occur within 0.5 mS of the onset of the active period [10].

To ensure that the characteristics of New Zealand circuits were similar to that reported for the French network, tests were carried out on several circuits between Christchurch and Auckland (about 800 km). A 5 microsecond rectangular pulse was used for these tests to simulate a Dirac impulse function. Figure 2 shows the results of these tests.

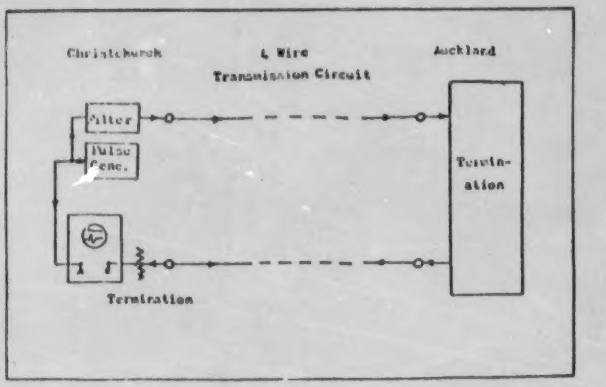
2. ECHO CANCELLER DESIGN

After due consideration of the various alternative echo canceller designs, we decided to opt for a rather unusual design approach. Firstly we would transmit a pseudorandom binary sequence down the line as a "test" signal, then correlate this signal to obtain a direct measure of the channel response. We used an $N = 10$ PRN generator, giving a sequence length of $2^N - 1 = 1023$ bits. Although this is not a Mersenne Prime sequence as recommended by Dixon [11], we found the sequence to be quite satisfactory. The nearest Mersenne Prime sequence is 127 bits which is too short, and the next is 8191 which is too long to correlate easily.

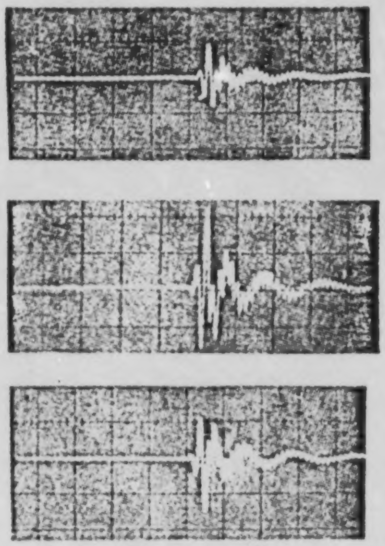
Figure 3 shows a block diagram of the channel response measurement circuit. A PRN sequence generator is used to provide one cycle of length 1023 bits, which is transmitted along the outgoing 4-wire line where the echo is to be measured. A pre-filter is used to protect the line against higher frequencies in the PRN sequence.

The echo from the outgoing sequence is correlated to obtain the impulse response of the channel. Coefficients from the correlator are stored directly in memory for use in echo cancellation. Although the correlator is a multiplier and accumulator, each multiplication is times 1 or 0, making it a simple add and accumulator. A 12 bit A/D converter is used to measure the channel response. Coefficients are stored in memory in true log format, with sign bit being stored separately.

Figure 4 is a block diagram of the UC/NZPO Echo Canceller itself. The output from the A/D converter changes speech to log format, with the sign bit being handled separately. The 12 bit



(a) Christchurch-Auckland telephone test circuit.



(b) Sample of echoes (2mS per division).

Figure 2. Measurement of echo response characteristics on a Christchurch-Auckland test circuit (800km).

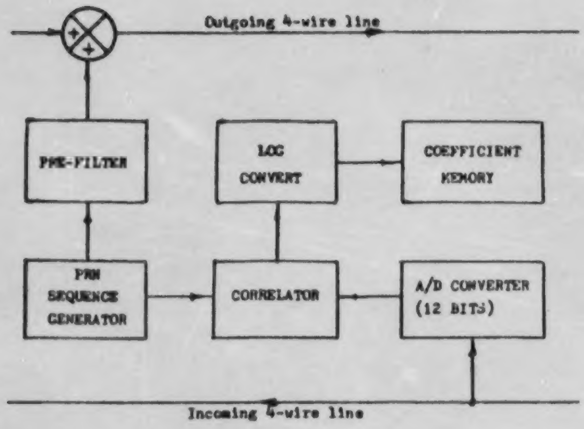

Outgoing 4-wire line
PRE-FILTER
LOG CONVERT
COEFFICIENT MEMORY
PRN SEQUENCE GENERATOR
CORRELATOR
A/D CONVERTER (12 BITS)
Incoming 4-wire line

Figure 3. Measurement of the channel response on the UC/NZPO Echo Canceller.

linear speech is converted to 7 bits plus sign in true log format. This allows speech samples and filter coefficients to be added rather than multiplied thus simplifying the convolution process. Sign bits are handled with a simple exclusive or gate. The products are converted with an antilog look up table prior to accumulation and D/A conversion. This echo estimate is subtracted from the return signal in analog form.

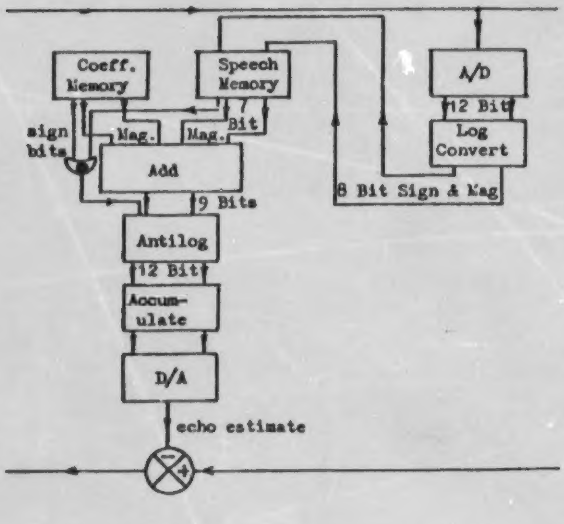

Coeff. Memory
Speech Memory
A/D
12 Bit
Log Convert
sign bits
Mag.
Mag.
7 Bit
Add
8 Bit Sign & Mag
9 Bits
Antilog
12 Bit
Accum-ulate
D/A
echo estimate

Figure 4. Echo Cancellation in the UC/NZPO system.

A total of 256 filter coefficients are used in the convolution and these are stored in RAM. This provides for a total impulse response length of 32 milliseconds, this being quite sufficient for all New Zealand conditions. Any delay prior to the active period of the impulse response is represented as zero amplitude coefficients and need not be catered for by separately delaying speech samples. Speech samples therefore become active immediately.

This echo canceller is designed to operate 32 channels in a time multiplexing mode, with a microprocessor used for programmed operation and mode switching. Generally speaking, the operational mode operates something like the following:

1. When the line connection is established, a single PRN sequence of length 1023 bits (128 milliseconds duration at 8k per second) is transmitted along the channel. The echo impulse response is calculated from correlation of the echo with the transmitted sequence. Constants are stored in log format for echo cancellation, and the channel is switched to "operate".

2. The system remains in "operate" mode until such time as a single-point correlator indicates that echo cancellation is no longer effective.

3. On command, the system switches back to 'calibrate" followed by reversion to "operate". Regular polling of all 32 channels is done by the microprocessor.

Figure 5 shows the mechanism by which the "out-of-calibration" measurement is made. The echo estimate is simply and continuously compared with the resultant corrected channel. Any correlation with this corrected signal means that the echo estimate is in error. If this error exceeds a predetermined value, the channel is "flagged" for recalibration on the next poll.

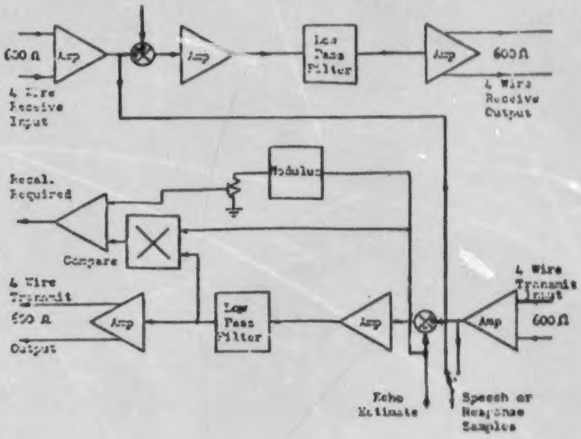

600 Ω
Amp
4 Wire Receive Input
Amp
Low Pass Filter
Amp
600 Ω
4 Wire Receive Output
Modulus
Recal. Required
Compare
4 Wire Transmit
600 Ω
Output
Amp
Low Pass Filter
Amp
4 Wire Transmit Input
Amp
600 Ω
Echo Estimate
Speech or Response Samples

Figure 5. Detection of "Out-of-Calibration".

The PRN sequence sounds like a subdued "hiss" on the line, and probably would not interfere with speech intelligibility, even though it is normally operated while speech is not present on the channel. Likewise speech does not interfere with the accuracy of calibration, because of the 128 millisecond averaging time. This averaging reduces the error due to the presence of speech during coefficient calculation, by 60dB.

Only two potential problems remain with this canceller. First, in a country such as the U.S., where transmission paths may be changed on an instantaneous basis, recalibration may need to be very frequent. Whether or not a frequent momentary "hiss" on the line would be acceptable is a question which we have not considered, since the problem does not exist in New Zealand.

The second potential problem is one of phase roll, due to non-synchronized oscillators in a multi-channel SSB frequency multiplexing system. We have analyzed this problem in detail, using the Hilbert Transform to calculate the vector filter coefficients [12], then roll the coefficients in accordance with the measured phase roll, in a manner identical to that published later by Gitlin and Thompson [13]. In this area our canceller appears to compare well with the more conventional correlative cancellers. But once again the occurrence of phase roll is statistically insignificant in the New Zealand network and so can be ignored.

3. TRUE LOGARITHMIC COMPANDING

Figure 6 shows the mechanism of true log companding. A 12 bit linear format in binary is used, with the 0 adjusted to the center of the A/D converter, between levels 0111 1111 1111 and 1000 0000 0000. This makes level 0111 1111 1111 be -0.5, while level 1000 0000 0000 is +0.5. Now if the sign bit is handled separately, the levels will be 0.5, 1.5, 2.5, etc. to 2047.5. If each of these is multiplied by 2 we have levels 1, 3, 5, etc. to 4095. Level 1 is log 0, and other levels are determined by the logarithmic base. Level 0 in linear does not exist, just as in the case of delta modulation.

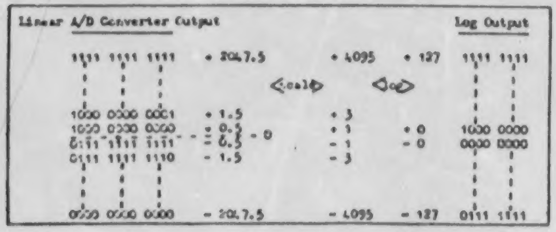


Figure 6. Offsetting, scaling and logarithmic conversion of linear binary numbers.

The true logarithm of levels 1 through 4095 are now scaled to 7 bits or 128 levels. This gives a log base of 1.06768. These are looked up in a simple PROM which has been programmed for this purpose. Sign bit, as mentioned previously, is carried and used separately.

Coding of speech and impulse response samples in a pseudo logarithmic format was proposed by Horna [14]. Horna's approach was similar in principle to ours, but his use of an A-law companding code introduced errors which do not occur in the true logarithmic companding code.

Actually there are 2 logarithmic companding codes in common use. The American (BTL) μ-law code was the earliest, followed by the largely European A-law code. For most purposes the major difference is that they are different, although the A-law is discontinuous, reverting to linear at the very low voltage levels.

Quantization noise in logarithmic format is a function of the amplitude of the signal. For an 8 bit companded signal in log format, the signal to quantizing noise ratio is +36 dB. Figure 7 is a plot of the comparison of SNR for true log, μ-law, and A-law companded systems, for 8 bit quantization.

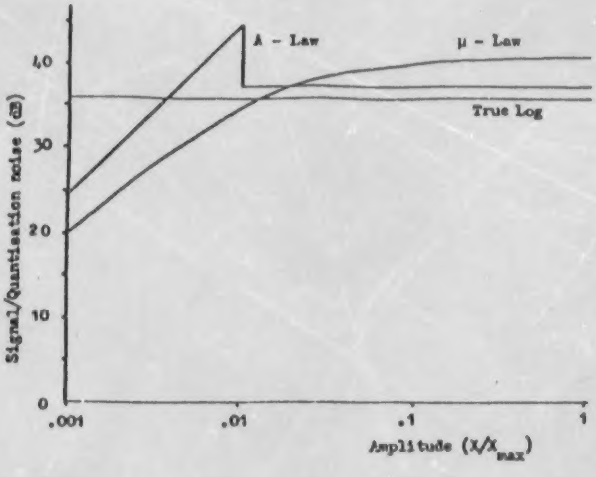


Figure 7. Quantization Error for various 8 bit compression curves.

Of course the main reason for going to a true logarithmic companding is the ease of computation. Echo cancellation coefficients which must be multiplied times the sampled data to produce echo estimate may now be added. Access time of a PROM, typically 50 nsec, converts the data from log to linear or linear to log.

4. CONCLUSION

The UC/NZPO Telephone Echo Canceller design seems to have certain advantages over correlative cancellers, such as (a) immediate channel "learning" by a PRN sequence, usually prior to the onset of voice communication, and (b) immunity to double-talk problems associated with correlative cancellers. True logarithmic campanding of voice gives a signal to quantizing noise ratio of +36 dB, regardless of the amplitude of voice over normal ranges. Quantizing noise is the limit of performance of the system, and echo cancellation will be fixed by the level of this quantizing error.

In cases of instantaneous switching of communication routes, where the echo will change, the UC/NZPO canceller must go through a detect and calibrate sequence, whereas the correlative canceller would automatically adapt to the new conditions.

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6. APPENDIX

6.1 TRUNCATED PRN SEQUENCE

To avoid a continuous transmission of the sequence, the transmission is truncated to a single cycle of 1023 bits, time length 128 mS. The auto-correlation function of a single sequence however is not the Dirac impulse function which is desired. To avoid noise due to minor false correlations in the truncated sequence, the sequence is extended for purposes of correlation.

Let s(kT) be a discrete representation of the interrogation signal, being one cycle of the pseudorandom sequence of length P, i.e. s(kT) is non-zero only for $0 \leq k \leq P$ and the discrete impulse response h(kT) is non-zero only for $0 \leq k \leq L$.

The response of the echo path to s(kT) is r(kT) and is necessarily confined to time period $0 \leq k \leq P+L$, i.e. r(kT) is non-zero only for $0 \leq k \leq P+L$.

Now s'(kT) is an extended version of s(kT) such that the cross correlation of these two functions approximates a Dirac Delta function in the manner that the auto-correlation of the pseudorandom noise sequence does, over the period of interest.

The discrete response r(kT) is given by the convolution of the transmitted signal s(kT) and the impulse response h(kT) plus any noise (including speech) n(kT) present at the time.

$$r(kT) = \sum_{i=0}^{L} s\{(k-i)T\}h(iT)+n(kT) \qquad \text{A-1}$$

Now the cross correlation of r(kT) and the function s'(kT) which is required to give $\delta h(kT)$, where δ is a constant, is given by:

$$\psi_{s'r}(kT) = \sum_{j=0}^{P+L} s'\{(k+j)T\}r(jT) \qquad \text{A-2}$$

the summation being over a limited range as r(jT) is non zero only for $0 \leq j \leq P+L$ as previously explained.

Substituting for r(kT)

$$\psi_{s'r}(kT) = \sum_{j=0}^{P+L} s'\{(k+j)T\} \sum_{i=0}^{L} s\{(j-i)T\}\cdot h(iT) + \sum_{j=0}^{P+L} s'\{(k+j)T\} n(jT) \qquad \text{A-3}$$

Introducing variable $\lambda = j-i$

$$\psi_{s'r}(kT) = \sum_{\lambda=-i}^{P+L-i} s'\{(k+i+\lambda)T\}\cdot \sum_{i=0}^{L} s(\lambda T)h(iT) + \sum_{j=0}^{P+L} s'\{(k+j)T\}n(jT)$$

$$= \sum_{i=0}^{L} \psi_{s's}\{(k+i)T\}h(iT) + \psi_{s'n}(kT) \qquad \text{A-4}$$

where $\psi_{s's}(kT)$ is the cross correlation of the transmitted signal s(kT) and function s'(kT).

h(iT) is the discrete impulse response

$\psi_{s'n}(kT)$ is the cross correlation of the function s'(kT) and any system noise n(kT) including speech with a maximum R.M.S. value of -17 dBmo.

Substituting $-m = k$ in A-4

$$\psi_{s'r}(-mT) = \sum_{i=0}^{L} \psi_{s's}\{(-m+i)T\}h(iT) + \psi_{s'n}(-mT) \qquad \text{A-5}$$

As h(mT) is known to be non zero only for $0 \leq m \leq L$

$\psi_{s'r}(-mT)$ is only of interest for $0 \leq m \leq L$ if

$\psi_{s'r}(-mT) = \delta h(mT)$

and for $\psi_{s'r}(-mT) = \delta h(mT)$

then;

$$\psi_{s'r}(-mT) = \sum_{\substack{i=0 \\ i \neq m}}^{L} \psi_{s's}\{(-m+i)T\}h(iT) + \psi_{s's}(0T)h(mT) + \psi_{s'n}(-mT) \qquad \text{A-6}$$

where $\psi_{s's}(0T)h(mT)$ is the $\delta h(mT)$ term.

As $\psi_{s's}(0T)$ will always occur in the range $0 \leq i \leq L$ for any $0 \leq m \leq L$, now the other two terms must approach zero.

$\psi_{s's}\{(-m+i)T\}h(iT)$ is the auto-correlation error

and

$\psi_{s'n}(-mT)$ is the noise error.

As the discrete impulse response h(iT) is known to be non zero only for $0 \leq i \leq L$ then $\psi_{s's}\{(-m+i)T\}$ must approach zero for $0 \leq i \leq L$ and $i = m$ over the range $0 \leq m \leq L$.

Therefore, $\psi_{s's}\{(-m+i)T\}$ must approach zero for $(-L+0) \leq (-m+i) \leq (L-0)$ and $i \neq m$.

therefore, $\psi_{s's}(kT) = 0$ for $-L \leq k \leq +L$ and $k \neq 0$

now $\psi_{s's}(kT) = \sum_{i=0}^{P} s'\{(k+i)T\}s(iT)$ as

s(iT) is non zero only for $0 \leq i \leq P$

now for $\psi_{s's}(kT)$ to approach zero for $k = 0$ when

s(iT) is a pseudorandom noise sequence

then $s'\{(k+i)T\}$ must be a shifted version of s(iT) for $k \neq 0$

and $s'\{(k+i)T\}$ must equal s(iT) for $k = 0$

The length of $s'\{(k+i)T\}$ is determined by the range of k and i;

$$-L \leq k \leq +L \quad \text{and} \quad 0 \leq i \leq P$$

then $s'\{(k+i)T\}$ must be an extended version of s(kT) over the range; $-L \leq k+i \leq P+L$.

Now $\delta h(mT) = \psi_{s's}(0T)h(mT) = \psi_{s'r}(-mT)$

and $h(mT) = (1/\delta)\psi_{s'r}(-mT)$ provided s'(kT) is an extended version of s(kT) for $-L \leq k \leq P+L$

therefore $h(mT) = (1/\delta)\sum_{i=0}^{P+L} s'\{(-m+i)T\}r(iT)$

The sequence s'(kT) is, therefore, an extended version of s(kT) in the positive and negative directions of length L. A diagram showing all of these functions as modelled for the pseudorandom binary sequence are shown in Figure A-1. The response to the sequence r(kT) was the actual response read from the memory of the canceller using these principles for obtaining the filter coefficients. The effect of auto-correlating the single cycle of the sequence without any extension results in the function $\psi_{ss}(kT)$, and the advantage of correlating the response with the extended sequence s'(kT) instead of s(kT) are obvious. The noise on the scaled impulse response $\psi_{sr}(kT)$ is the noise due to using the unextended sequence for correlation purposes.

If the amplitude of s(kT) is +/- V_s and the amplitude of s'(kT) is $V_{s'}$ the amplitude of the cross correlation function $\psi_{s's}(kT)$ will be $+PV_sV_{s'}$ at $k = 0$ and $-V_sV_{s'}$ for k non zero and $-L \leq k \leq +L$. Outside this range the function will have some random value but is out of the range of consideration. The cross correlation function $\psi_{s's}(kT)$ remains only an approximation to a Dirac Delta function even within the range of interest as it is non zero when k is non zero.

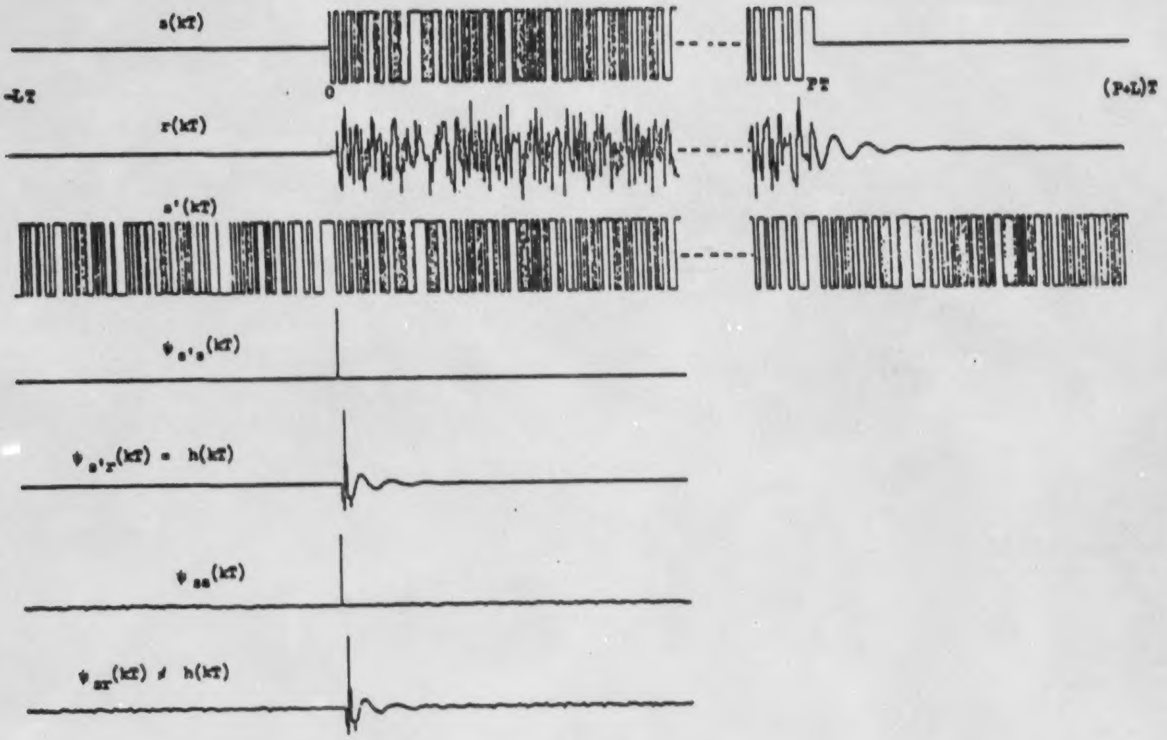
s(kT)
-LT
0
PT
(P+L)T
r(kT)
s'(kT)
ψ s's(kT)
ψ s'r(kT) = h(kT)
ψ ss(kT)
ψ sr(kT) ≠ h(kT)

Figure A-1. Functions Involved in Impulse Response Measurement.

Characteristics of the Hard Limiter

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Abstract

Adding two signals together linearly and subjecting the sum to hard limiting can be used as a modulation, demodulation, or sampling process. Class D audio amplification is a well known example of this process. Although a triangular "bias" waveform is normally used for class D audio amplification, it is shown that for most purposes a sinusoidal bias waveform is superior. The hard limiter is shown to be an efficient modulator to produce AM and AMSC at comparable efficiencies with that normally associated with class D audio amplifiers (80% to 90%). Use of a subharmonic bias or carrier frequency permits demodulation of SSB, AM, AMSC, and narrow bandwidth angle modulation with good linearity. Zero crossings can also be used to produce a sampling system with characteristics that are somewhat more controllable than conventional impulse sampling systems.

1. INTRODUCTION

In a recent investigation into the effects of limiting in reducing impulse noise [1], it became obvious that the capability of hard limiters in a number of areas had not been fully exploited. The hard limiter is very similar to a balanced mixer in some respects but operates to an entirely different set of rules. A hard limiter will normally remove any amplitude information from the input signal.

Early work by Licklider and Pollack [2], suggested that a hard limiter did not necessarily distort a signal, particularly if a "bias" signal was added to control the action of the hard limiter. This early work was not followed up however to produce any new applications of limiters in the modulation field. The addition of the bias signal changes the action of the hard limiter in a very fundamental way. The bias signal tends to control the action of the limiter and effectively linearises the characteristics so far as the smaller amplitude signal is concerned. This leads to some useful applications of the hard limiter as both an amplitude modulator and a demodulator of a wide range of information bearing signals including narrow bandwidth FM.

The class D audio amplifier is a very practical example of the use of a hard limiter as a modulator. In this case a bias signal above the audio frequency band is added to voice or music. The sum voltage is applied to a hard limiter and the higher bias frequency is then filtered from the output to leave only the audio frequencies. The bias frequency in this case has simply acted as a catalyst to linearise the action of the limiter making it possible for highly nonlinear switching elements to be used for linear audio amplification.

2. THEORETICAL ANALYSIS

Consider the case of the ideal limiter as shown in Figure 1 with a transfer characteristic

$$g(x) = \begin{cases} +1 \text{ for } x > 0 \\ \;\;0 \text{ for } x = 0 \\ -1 \text{ for } x < 0 \end{cases} \qquad (1)$$

and whose input signal is the sum of two sinusoids such that

$$x(t) = S_1(t) + S_2(t)$$

$$= V_1 \cdot \cos\,(w_1 t + \emptyset_1) + V_2 \cdot \cos\,(w_2 t + \emptyset_2) \quad (2)$$

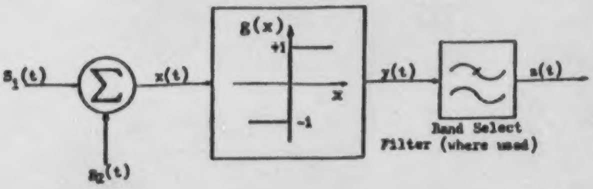


Figure 1. An Ideal Limiter With Two Input Signals.

From Jones [3] the autocorrelation function of the hard limiter output $R_y(\tau)$ is given by

$$R_y(\tau) = \sum_{m=0}^{\infty}\sum_{n=0}^{\infty} \epsilon_m \epsilon_n \cdot h_{mn}^2 \cdot \cos(mw_1\tau) \cdot \cos(nw_2\tau) \quad (3)$$

where ϵ_m, ϵ_n, are Neumann Factors, and

$$\epsilon_i = \begin{cases} 1 \text{ for } i = 0 \\ 2 \text{ for } i > 0 \end{cases} \qquad (4)$$

The coefficient h_{mn} is defined as

$$h_{mn} = \begin{cases} \frac{2}{\pi} \cdot (-1)^{\frac{m+n-1}{2}} \cdot \int_0^\infty \frac{J_m(uV_1) . J_n(uV_2)}{u} du & m+n \text{ odd} \\ 0 & m+n \text{ even} \end{cases} \quad (5)$$

where $J_m(\cdot)$ is the mth order Bessel function of the first kind. The condition that the h_{mn} factors are non zero only for odd integral values of the sum $(m+n)$ is a consequence of the odd symmetry of the hard limiter amplitude characteristic. This forces the limiter output to have only those spectral components lying in the vicinity of the odd harmonics of the input frequencies.

The resolution of these spectral components involves the solution of (3) since the spectral density is the Fourier Transform of the autocorrelation function [4]. It is convenient at this point to introduce the ratio A where A is defined as the amplitude ratio of the two input signals ("bias" to signal amplitude ratio) such that

$$A = \frac{V_2}{V_1} \quad (6)$$

There are two cases which are of special interest

(i) $A = 1$
(ii) $A >> 1$

Although the solution is complex and is not shown here the following results can be derived [5-8]. For A=1,

$$P_{mn} = \begin{cases} \frac{32}{\pi^4 [m^2 - n^2]^2} & \text{for } m\underline{+}n \text{ odd} \\ 0 & \text{for } m\underline{+}n \text{ even} \end{cases} \quad (7)$$

where P_{mn} is the power in the $(m\underline{+}n)$ spectral component.

Considering $S_1(t)$ and $S_2(t)$ as equal amplitude sinusoids (A=1) and assuming $w_2 = 20w_1$ then the resulting limiter spectrum is shown in Figure 2. In the baseband region (n=0) only the odd harmonics of w_1 are present since m must be odd due to the $(m\underline{+}n)$ odd rule that exists for the balanced limiter output. It is interesting to note that these harmonics of w_1 occur in the same ratio as a triangular wave i.e. their amplitudes are proportional to the reciprocal of the square of the harmonic order as predicted by (7).

In the case of a limiter used for a class D audio amplifier, significant odd harmonics would be produced as the voice/music amplitude approached that of the bias signal. Figure 3 shows the spectrum produced when a triangular waveform is used as a bias signal. Here the odd harmonics of w_1 have disappeared from the baseband (n=0) spectral region but the higher order region of the spectrum has not been significantly simplified.

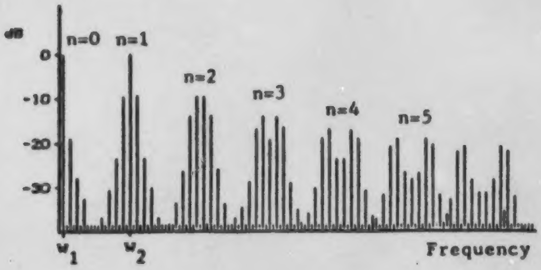


Figure 2. Hard Limiter Output Spectrum For Two Equal Amplitude Sinusoidal Inputs.

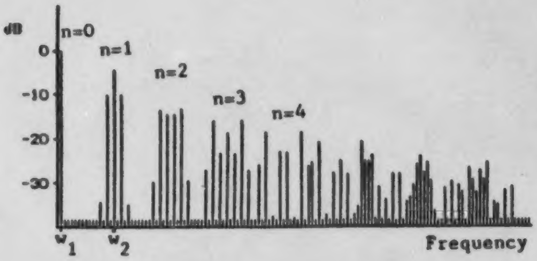


Figure 3. Hard Limiter Output Spectrum For Equal Amplitude Sinusoid and Triangular Input Signals.

For A >>1,

$$P_{mn} = \begin{cases} 2 \left[\frac{\Gamma\left[\frac{m+n}{2}\right]}{\pi A^m m! \Gamma\left[1+\frac{n-m}{2}\right]} \right]^2 & \text{for } m\underline{+}n \text{ odd} \\ 0 & \text{for } m\underline{+}n \text{ even} \end{cases} \quad (8)$$

where $\Gamma(\cdot)$ is the Gamma function and P_{mn} the power in the $(m\underline{+}n)$ spectral component. This is a considerable simplification from that obtained by Jones [3] and Davenport [7] and has been made possible by the assumption that A>>1. The spectrum of the limiter output for sinusoidal bias and A=10 is shown in Figure 4. This spectrum which is normalised to the baseband signal w_1(m=1,n=0) is now greatly simplified. This implies a linearisation of the non-linear hard limiter characteristic as far as the smaller amplitude baseband signal is concerned. The spectral component at w_2(n=1) is 26dB greater than w_1(m=1).

This is due to the 20dB from the 10 to 1 input amplitude ratio plus an extra 6dB of "small signal suppression" as predicted by Jones [3] for large amplitude ratios.

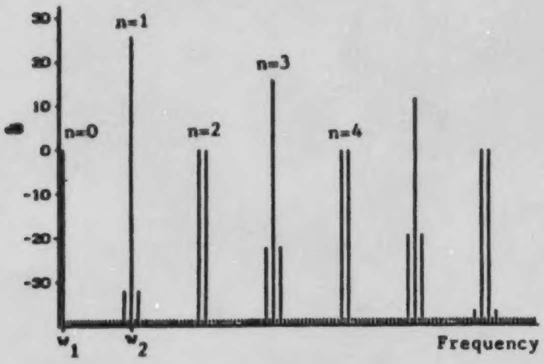


Figure 4. Hard Limiter Output Spectrum For Sinusoidal Input Signals and A=10.

The baseband harmonics have now disappeared and the spectral region around w_2 has been simplified. The only significant spectral lines about w_2 are $w_2 \pm 2w_1$ which are 60dB below w_2 in amplitude. Sinusoidal bias using high values of A (>10) linearises the limiter characteristics and greatly simplifies the resulting spectrum. However the amplitude ratio of bias to signal in the output spectrum is high and it would be desirable to see this ratio reduced.

3. THE LIMITER AS A MODULATOR

A modulation process implies a linear frequency translation of some baseband signal to a higher frequency which is dependent on the "carrier" frequency. In Figure 4 only a single pair of spectral lines dominate in the n=2 spectral region. These are $2w_2 \pm w_1$ which resembles amplitude modulation suppressed carrier (AMSC). The only difference is that the modulation sidebands appear at twice the bias frequency as opposed to the carrier frequency. Filtering out this region verifies that an AMSC waveform is produced. These same modulation sidebands repeat at all the even harmonic regions of the bias frequency with only slowly increasing distortion. The suppressed carrier waveform exists of course because only the odd harmonics of w_2 are permitted to be present in the balanced limiter configuration.

If the hard limiter characteristic is now unbalanced so that it becomes a level crossing detector as opposed to a zero crossing detector as in the balanced case, then the odd symmetry no longer exists and even harmonics of both input signals can now occur. The result of this change of symmetry is shown in Figure 5 where the only significant change is the appearance of the even harmonics of the bias frequency with the result that a "carrier" appears between the modulation sidebands to produce an AM spectrum. This result has been verified in laboratory experimental apparatus. The level of "carrier" present can be controlled either by the degree of unbalance of the limiter or by adding a DC voltage to the input waveform. This gives an effective modulation index which is independent of the bias level.

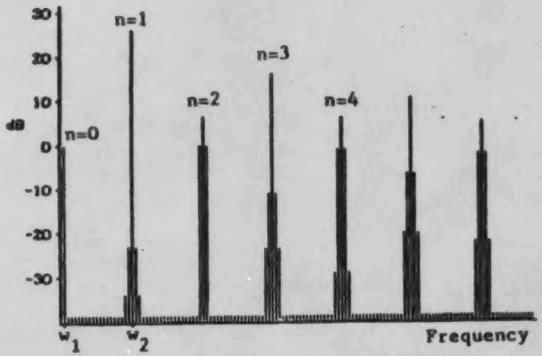


Figure 5. Unbalanced Limiter Spectrum For Sinusoidal Input Signals and A=10.

The hard limiter then, can act as a very good AM or AMSC modulator. The "carrier" frequency of such a modulator will be at $2w_2$ (twice the bias frequency) with the major interfering frequencies to be removed being at w_2 and $3w_2$ which should be relatively easy to filter even at high power levels.

Figure 6(a) shows an experimental class D audio amplifier with an inductive input audio filter (low pass) and Figure 6(b) shows an inductive input bandpass filter for an AM modulator.

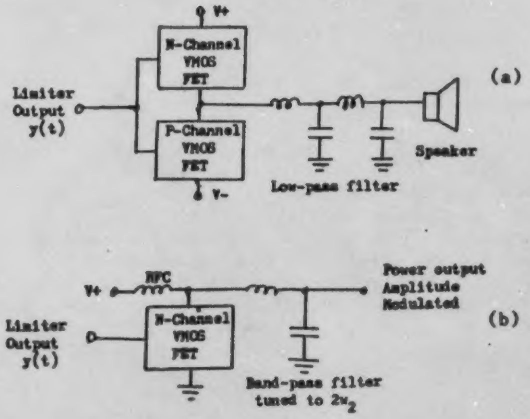


Figure 6. Block Diagrams of (a) an Experimental Class D Audio Amplifier and (b) an Experimental Amplitude Modulator.

Results of efficiency measurements on a class D audio amplifier of this design compared with a class AB audio amplifier are shown in Figure 7. Although the class D audio amplifier shows higher efficiency at all power levels, it is at the low power levels that the class D excells. Since even high level voice or music show very low average levels, practical comparisons of efficiency of these two amplifiers should greatly favour the class D system.

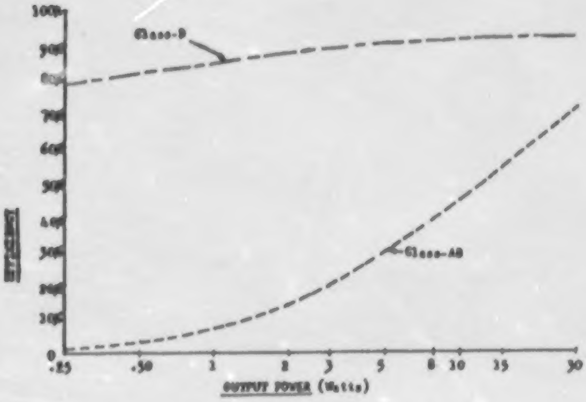


Figure 7. Efficiency Curves For an Experimental Class D Audio Amplifier and a Class AB Audio Amplifier.

Although it has not been verified in a practical system the AM modulator of the design in Figure 6(b) would be expected to exhibit efficiency of 80-90% provided that efficient high switching speed transistors are used. The VMOS FET switching transistors show considerable promise at moderate frequencies with switching speeds of 2-5 nanoseconds under favourable conditions.

Although high amplitude ratios ($A >> 1$) tend to linearise the limiter output, the ratio of bias to signal tends to reduce the time deviation in the zero crossing region. This means that the switching circuits are handling mostly bias power when the modulation or audio power should be emphasised. To correct this situation a limited duty cycle waveform can be used which effectively reduces the bias power in the modulated waveform. The conversion from the bilevel limiter output waveform to the "trilevel" waveform is shown in Figure 8.

The result of removing the redundant bias power is shown in Figure 9 for A=10. The pulse width has been reduced to the minimum width so as to just avoid any overmodulation. The effect is to drastically reduce the level of bias power (and its harmonics) in the output spectrum thus making the output more efficient. The bias power is still however 6dB greater than the signal power since the "small signal suppression" effect still occurs through the hard limiter. The analogy to AM where the carrier is 6dB higher than the modulation sidebands may be noted.

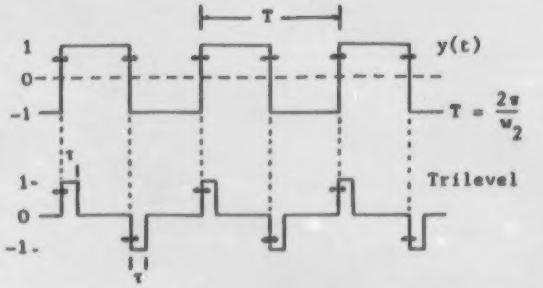


Figure 8. Conversion of the Bilevel Limiter Output Waveform to the Trilevel Waveform.

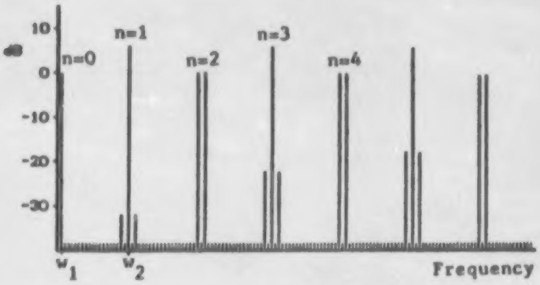


Figure 9. Spectrum of the Sinusoidally Modulated Trilevel Waveform.

The limiter output spectrum occurs in groupings at all the multiples of n with n-odd regions being bias components and n-even spectral regions being modulation sidebands. For high values of A the spectrum is very repetitive apart from spurious sidebands around the n-odd regions. These tend to increase in amplitude with increasing n. This tendency is to be expected for finite values of T/τ with the spectrum approaching "ideal" for $\tau \to 0$ as with the Dirac Delta function.

3.1 SIMULATION

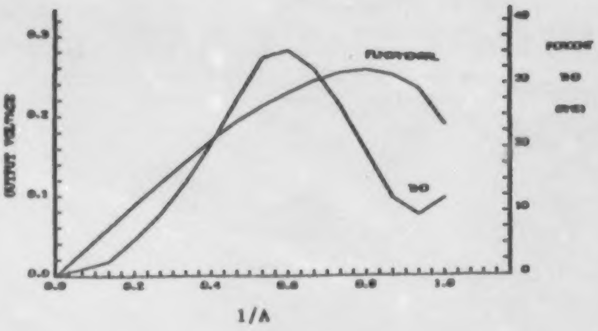
All of the spectral results presented were obtained by digital computer simulation of the system shown in Figure 1. A Fast Fourier Transform (FFT) algorithm is used to obtain the spectrum of the limiter output y(t). The bilevel and trilevel waveforms have been developed experimentally and both voice and music have been passed through the modulation process without detectable distortion provided the ratio A is high.

4. THE LIMITER AS A DEMODULATOR

It is a well known fact that a hard limiter destroys any amplitude information present on a signal (e.g. FM detectors). However if a high amplitude bias signal is also applied to the limiter then the amplitude information bearing signal suffers little distortion. If the AM signal present at the n=2 spectral region of Figure 5 is subjected to hard limiting, no baseband information results. This effect is of course predictable mathematically from the $(m \pm n)$ odd rule. In this case the "carrier" order n is 1 and the sideband order m, is also 1 resulting in an even sum and no baseband output from the demodulator. However if a high amplitude half-frequency carrier is introduced then the baseband signal can be recovered since $(m \pm n)$ is now odd and the difference results in baseband reconstruction. Provided the amplitude ratio between the subharmonic bias and the information bearing signal is high, demodulation is quite linear. Experiments with sinusoidal signals have shown a very linear relationship between input and output of the limiter for the smaller amplitude input signal.

Subharmonic injection followed by hard limiting will demodulate both single and double sideband amplitude modulated signals. This does however assume that a subharmonic bias is available at the receiver of the correct frequency and phase for synchronous detection to take place.

Digital computer simulation was used to display the results of the detection process. A Newton Raphson algorithm is used to accurately solve for the times of the zero crossings of the modulated waveform. The variation in zero crossing intervals is at the modulation rate thus yielding the demodulated waveform. Figure 10(a) is the time plot for SSB demodulation shown for one cycle of the modulation signal. This is the waveform that would appear as z(t) in Figure 1 after low pass filtering the limiter output. A number of different waveforms are shown emphasising the distortion at low values of A. A synchronous subharmonic carrier is assumed for the demodulation.



(b)

Figure 10. Limiter Demodulator Output for SSB as (a) a Time Waveform and (b) Fundamental Amplitude and THD for a Range of A.

To obtain a direct measurement of the quality of demodulation, a Fourier series is matched to the fundamental sinusoidal modulation allowing total harmonic distortion (THD) calculations to be made. Figure 10(b) shows these results, giving both the fundamental amplitude and THD for decreasing values of A.

Figure 11 shows similar results for AMSC demodulation. The limiter demodulator suffers from the same problems as conventional synchronous detectors if phase or frequency error exists on the subharmonic bias frequency. The "quadrature null effect" occurs for a double sideband system except that the null occurs at 45 degrees phase error on the bias as opposed to 90 degrees on the conventional "carrier" due to their two to one frequency relationship.

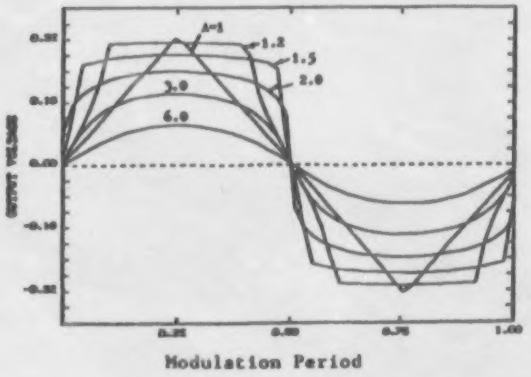


Figure 10 (a)

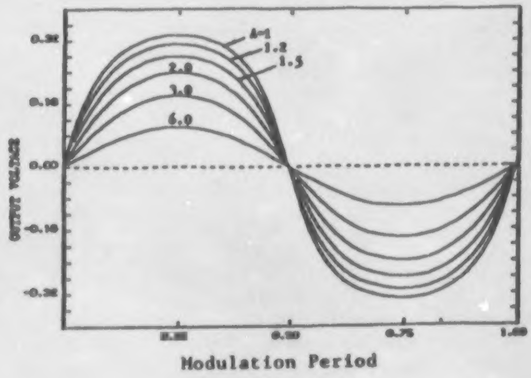
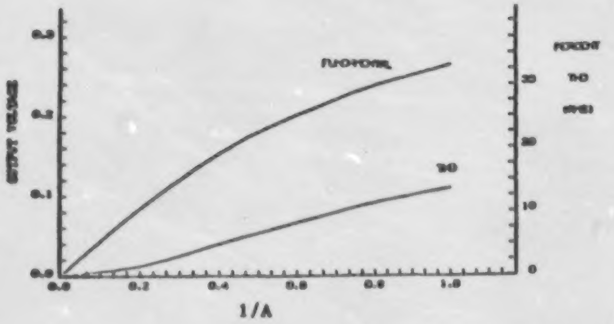


Figure 11 (a)



(b)

Figure 11. Limiter Demodulator output for AMSC as (a) a Time Waveform and (b) Fundamental Amplitude and THD for a Range of A.

The demodulation results for an AM waveform are shown in Figure 12. The presence of the carrier in the waveform results in an assymmetrical time waveform and the total harmonic distortion rises more rapidly than that of AMSC. Just as the AM carrier is supplied in the case of the modulator by deliberately unbalancing the limiter, the AM carrier offsets the limiter output in the case of the demodulator and even harmonic distortion occurs.

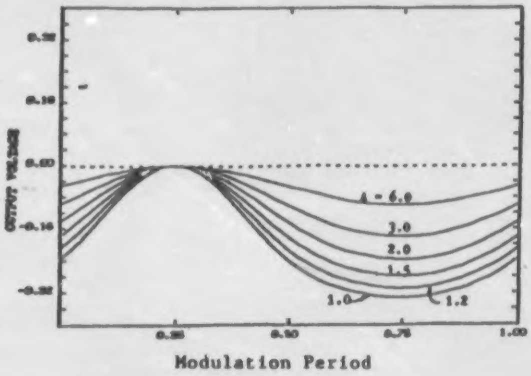
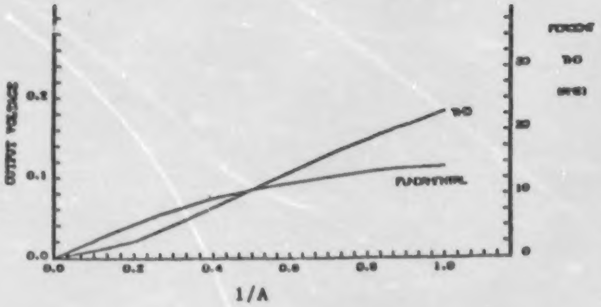


Figure 12 (a)

Low modulation index angle modulated waveforms have a spectrum not significantly different from that of AM i.e. a small number of modulation sidebands. The major difference is the quadrature phase relationship between adjacent sidebands. The hard limiter performs "single projection" detection of narrowband FM signals in that either the even or odd order sidebands are demodulated depending on the relative phase of the bias. Detection of the odd order sidebands allows the



(b)

Figure 12. Limiter Demodulator Output for AM (100%) as (a) a Time Waveform and (b) Fundamental Amplitude and THD for a Range of A.

baseband signal to be recovered and provided the modulation index is small (<1) the odd harmonic distortion is minimal. Figure 13 shows the resulting time waveform and distortion for various values of A for a modulation index of unity. A high value of A is again necessary for linear recovery and the FM detector is restricted to low values of modulation index as reconstruction of the higher order sidebands is more complex.

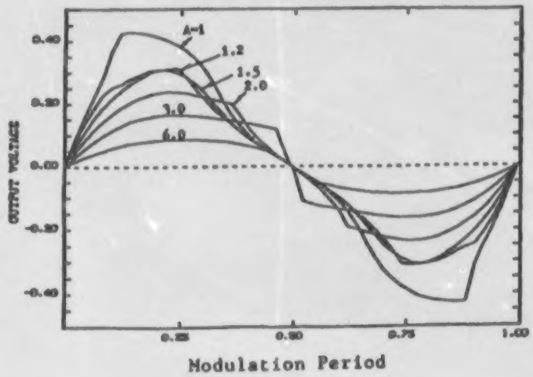
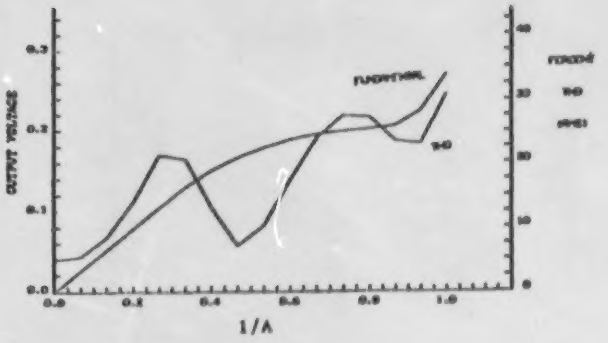


Figure 13 (a)

5. THE LIMITER AS A SAMPLER

When considering the limiter as a modulator the spectrum is repetitive (Figure 9), alternating between bias components in the n-odd region and a single pair of sidebands in the n-even spectral region. This is for the trilevel waveform of Figure 8 whose width varies from zero to twice the unmodulated width (τ). Provided the amplitude



(b)

Figure 13. Limiter Demodulator Output for Narrowband FM (modulation index = 1) as (a) a Time Waveform and (b) Fundamental Amplitude and THD for a Range of A.

ratio A is high, the sidebands around the bias components (n-odd) become insignificantly small. Considering $S_1(t)$ to contain a finite modulation bandwidth then the spectrum appears as in Figure 14. The repetitive nature of the modulation bandwidth as a function of frequency is now exactly as in any other sampled data system. As long as the width of the trilevel pulse (τ) is kept narrow with respect to the period T, the limiter converted to trilevel output becomes identical to an equivalent sampled data system.

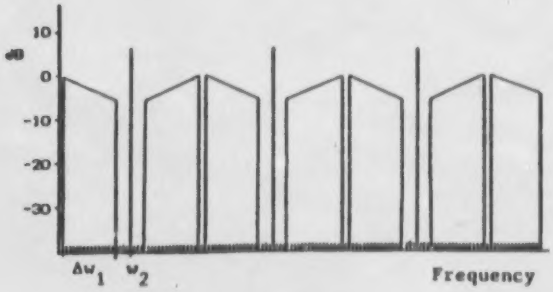


Figure 14. Spectrum of the Modulated Trilevel Waveform with a Finite modulation Bandwidth and A=10.

Some other interesting waveforms of a similar shape are the Walsh functions [9,10]. The relationship of two of these as derived from the limiter waveform is shown in Figure 15 where Wal 1 is a first order Walsh function and Wal 2 is a second order Walsh function of the first kind.

The central transition of the function is modulated in position with the result as shown in Figure 16 of suppressing the bias component provided τ is small compared with T.

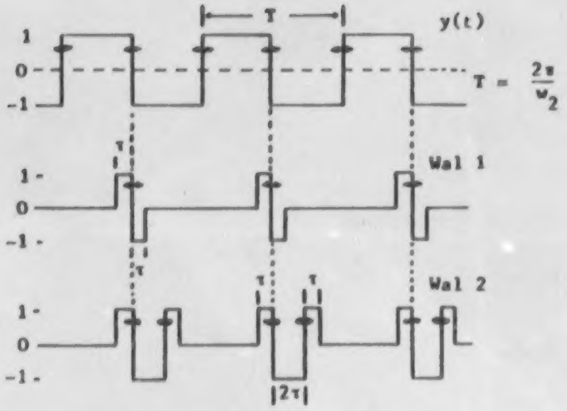


Figure 15. Conversion of the Limiter Output Waveform to a Walsh Function.

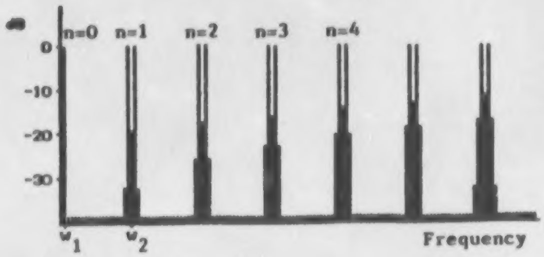


Figure 16. Spectrum of the Sinusoidally Modulated Wal 1 Function.

As T/τ becomes very large such that τ approaches the width of a Dirac Delta function then the spectrum becomes a series of equal amplitude sidebands just like an ideal sampling function with the sampling frequency itself suppressed. This is shown in Figure 17 for a finite bandwidth information signal.

The Wal 2 function is more complex in shape with the two central transitions being modulated in position but in opposite directions. The result as shown in Figure 18 is an idealised series of AM waveforms at multiples of the sampling frequency with the carrier 6dB higher than the modulation sidebands.

6. CONCLUSION

The limiter can be of significant value as a modulator, demodulator, or a sampler. As a modulator, it should prove valuable as an efficient amplifier of difficult waveforms such

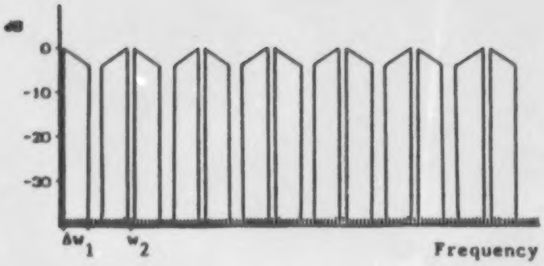


Figure 17. Spectrum of the Modulated Wal 1 Function for a Finite Modulation Bandwidth.

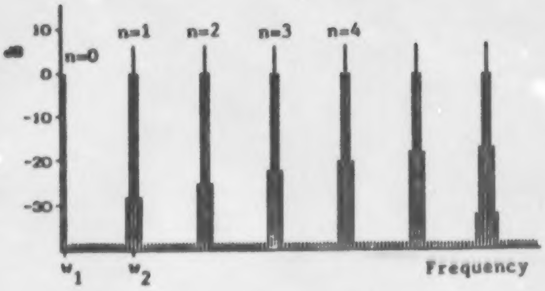


Figure 18. Spectrum of the Sinusoidally Modulated Wal 2 Function.

as AM. As a demodulator it offers an alternative form of demodulation, which seems to have certain advantages, such as in the demodulation of AMSC or overmodulated AM. As a sampler it offers all the advantages of impulse sampling by simply utilizing the transition regions of the limiter-comparator. Furthermore it allows alternatives in sampling, such as the suppression of the sampling frequency itself, or the generation of special waveforms such as AM.

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Transmission of Two High Quality Video Signals Over a Single Terrestrial Microwave Channel

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Abstract

In many areas, frequency allocations for terrestrial radio links are difficult to obtain because of spectrum congestion. A new video transmission technique in which two video channels are conveyed within the frequency allocation assigned to a single microwave channel has been utilized to double the video capacity of a microwave link. The performance of the new system is fully comparable to that achieved with prior transmission techniques yielding high quality television pictures that should meet the stringent requirements of both broadcasters and the cable TV industry.

1. INTRODUCTION

The burgeoning growth in the utilization of communication satellites for the distribution of television signals (primarily for the cable television industry, but also for network broadcasters) has created a corresponding increase in the demand on the frequency spectrum. This resource, which is becoming increasingly scarce, is administered or allocated by the Federal Communications Commission (FCC). The frequency allocation (which amounts to permission to use a certain portion of the spectrum) is reserved for use by a communications common carrier, such as RCA Americom and is granted only after the applicant has coordinated the proposed usage with all other users in the area.

Since video transmissions originate from TV studios located in metropolitan centers, while transmission to the satellite originates at earth stations that are usually located far from the center of the city, a terrestrial microwave radio link is needed to convey the signals to the earth station. Additional frequency allocations for these microwave links are extremely difficult to obtain due to the congestion of the airwaves. RCA Americom has recently installed a new video transmission system on its terrestrial microwave link between New York and its major video satellite transmission facility at Vernon Valley, New Jersey, in which two video channels are carried within the frequency allocation assigned to a single microwave channel. This doubles the video transmission capacity of the facilities without a concomitant increase in required frequency allocations.

The performance of the new system is fully comparable to that achieved with prior transmission techniques, yielding high quality television pictures that should meet the stringent requirements of both broadcasters and the cable TV industry.

2. SYSTEM DESCRIPTION

2.1 CONVENTIONAL (SINGLE VIDEO TRANSMISSION)

To better understand the considerations that led to the new transmission system, which achieves a doubling of video capacity, a brief description of the prior conventional one-channel system will prove helpful. Video signals originating from New York City are transmitted to RCA Americom's satellite for further distribution. The communications satellites are accessed via Americom's earth station located at Vernon Valley, N.J. The video signals are conveyed from New York City to Vernon Valley via a terrestrial link consisting of three "hops". The first hop out of New York City is the longest (32 miles) and is at a frequency in the 6-GHz band. The other hops are much shorter (11 miles and 2 miles) and utilize frequencies in the 11-GHz band. The transmission technique used previously, employed a single carrier located in the center of a band of frequencies allocated to the path. In addition to the video signal, one or more audio channels are carried by frequency modulating separate subcarriers and combining these subcarriers with the video signal to produce an extended baseband, which is then used to frequency modulate the single rf carrier. The bandwidth required to carry this information without imparting any moticeable distortion to the TV signal is a function of the frequency deviation of the rf carrier, maximum baseband frequency, and number and spectral location of the audio subcarriers.

The typical terrestrial system uses a peak deviation of 4 MHz due to video alone, and since the video signal falls off considerably in spectral content above 4.2 MHz, the amount of bandwidth required to convey the video information alone is approximately 14 to 16 MHz for an excellent (broadcast) quality signal. The bandwidth allocated for video transmission at 6 GHz is 30 MHz wide which is much more than is required, as shown in Fig. 1. When audio is conveyed over the same microwave channel as the video, the bandwidth required will increase unless the deviation due to the video is reduced. The increased bandwidth required for video and audio is still well within the allocated bandwidth of 30 MHz for 6 GHz carriers and 40 MHz for 11 GHz carriers. This conventional system provides a full broadcast quality signal and has been the standard transmission technique.

2.2 NEW (DUAL VIDEO) TRANSMISSION TECHNIQUE

The approaches that were considered to increase the video transmission capacity of the microwave link were confined to those that provided signal quality virtually indistinguishable from the conventionally transmitted signal. It was also decided to utilize a system that would use the same power limits, be within the same allocated bandwidth, and meet the same out-of-band emissions limits as are currently specified for the conventional video system in order to facilitate obtaining FCC authorization.

The approach chosen, which meets all of the above criteria, is as follows. Instead of a single carrier located in the center of the allocated bandwidth, two separate carriers are utilized, each offset in frequency from the center of the band as shown in Fig. 1(b). Each carrier is frequency modulated by video program material. The video signals are completely independent and no synchronization between them is required. The operational parameters such as frequency separation between carriers, frequency deviation due to the video signal, and strength of each carrier were chosen to optimize the performance characterized by signal to noise ratio, various video distortion parameters, intermodulation and crosstalk, and FCC regulatory constraints. The dual carrier approach may be implemented in many different ways, with the specific implementation having profound effects on performance over the New York to Vernon Valley terrestrial link. As we examine the implementation for this particular link, the system considerations involved will become clear and the applicability to other terrestrial paths highlighted. A block diagram of the basic system is shown in Fig. 2. All components such as modulators, transmitters, receivers, circulators, and bandpass filters off-the-shelf items which have been designed for conventional video transmission.

System operation is described by starting in New York at the transmit site where there are two separate video modulators and two separate transmitters. The transmitters operate on adjacent frequencies separated from each other by approximately 16 MHz. Each transmitter is operated at the same (maximum) power as it would operate at for conventional operation. Although the traveling wave tubes (TWT), which provide the final power amplification, are operated in a saturated mode which is inherently highly nonlinear, this does not cause any difficulty at the origination site in New York because each transmitter is only handling a single carrier. The output of the two transmitters is combined in a summer which is a purely passive device (a magic tee in this case). The magic tee combiner provides isolation between the transmitters and also introduces a 3 dB loss in each carrier so that the total power radiated is the same as for a single transmitter before the combiner. The output of the combiner consists of two frequency modulated carriers which are offset in frequency and therefore do not overlap or interfere with each other. Both carriers are sent through the same bandpass filter and circulator (which is part of the conventional branching network), combined with the other transmissions from the New York site and radiated from the transmitting antenna to the first repeater site, at Greenpond, 32 miles away.

At the Greenpond repeater, after reception at the antenna, the two carriers are passed through the microwave bandpass filter which is turned to reject all received signals except the two carriers in the desired frequency band. Again, this is still conventional. Both carriers are now simultaneously fed to the single receiver which is tuned to the center of the frequency band. In other words, at the repeater, the receiver's local oscillator is at the same frequency for two-for-one transmission as for conventional transmission. The output of the receiver (in the 70-MHz range) is fed to the single transmitter whose output is then (after passing through the conventional branching network) radiated to the next repeater located at Vernon Valley (about 11 miles away). The local oscillator for the transmitter (at the repeater) is tuned to the center of the frequency band and is therefore at the same frequency for single video or two-for-one video transmission.

We have been using conventional components, tuned to the standard frequencies (except for the offset carriers transmitted from New York). However, the fact that this technique has both carriers simultaneously in the same receiver and transmitter (at the repeater sites) has several implications on operation that differ from the single video operation.

The reason that two-for-one video requires a change in operation arises from the nature of the signals that are carried by the repeaters. A frequency modulated carrier has essentially no amplitude fluctuations. However, two frequency modulated carriers (one for each video channel) have significant amplitude fluctuations. Therefore, any nonlinear effects that would cause distortions on amplitude varying signals must be accommodated whereas these same nonlinearities could be ignored previously.

Fortunately, the nonlinearities involved may be dealt with in a simple manner which allows a practical system to be attained. One major nonlinearity is due to the output TWT of the transmitter. To overcome this nonlinearity, one can operate the TWT in a linear mode by backing off (or attenuating) the input signal a sufficient amount. This of course reduces the output power from the TWT. However, on this particular path between New York and the earth station at Vernon Valley, the hop out of New York dominates the link performance. But here two TWT's are used, each at saturation; therefore, there is no significant loss in performance. The reduction in power from the transmitters at Greenpond and Vernon are not large enough to cause these hops to introduce any significant effects on performance. The system calculations and measured performance, presented later, will verify this.

The backoff must also be sufficient to ensure that the constraints on out-of-band emissions and crosstalk are satisfied. The required backoff is a function of the TWT and upconverter nonlinearities as well as the nominal output level from the IF amplifier feeding the transmitter upconverter. With the parameters obtained for the microwave equipment installed on the New York to Vernon Valley path, an output backoff at Greenpond of about 12 dB for each single carrier (or 9dB total) is sufficient to provide excellent performance.

There was one additional potential source of nonlinearity that is present in terrestrial microwave systems that was necessary to investigate before a viable system could be configured.

Due to the nature of terrestrial propagation at microwave frequencies, it is expected that at times a significant amount of signal fluctuation may occur. Fluctuations of 20 to 40 dB may occur and the system must be designed to accommodate them. At each receiver an i-f amplifier is used which maintains the signal fed to the transmitter upconverter at a constant level (i.e., independent of fluctuations). There are a number of ways of accomplishing this, and the various manufacturers of radio equipment take different approaches.

One approach is to operate the i-f amplifier in a saturated mode with limiters used to maintain signal level. A different approach is to sense any variations in the output level and actually adjust the gain of the amplifier to accommodate the fading. Since the fading is a relatively slow phenomena, the automatic gain control (AGC) circuits are set to respond to these slow variations. These two approaches, while both adequate for single video operation, affect the two-for-one video operation in very different ways.

The first approach (using hard limiting) does not work with amplitude varying signals as it tends to eliminate all amplitude fluctuations. This leads to excessive intermodulation and crosstalk and is not acceptable.

The second approach (true AGC sensing) utilizes circuitry which responds to the slow (fading) variations and keeps the i-f output level insensitive to those variations. On the other hard, the AGC circuits will not respond to the much faster fluctuations due to dual carrier operation. This has the effect of introducing a nonlinear gain for slow fading and a linear gain for the fast fluctuations. It turns out that the linearity of the i-f amplifier is sufficient to permit dual carrier operation with excellent performance, as verified by testing in an operational link.

At the last receiving site (Vernon Valley) the two carriers are separated from each other and the two video signals demodulated. The separation is accomplished by having each receiver tuned to the frequency of one of the carriers and employing a narrow band (about 16-MHz wide) bandpass filter to accept the desired carrier and reject the undesired carrier.

The system which has been described above has been implemented on the New York to Vernon Valley terrestrial path. The fully operational system is a protected service (hot standby) as shown in Fig. 3. The performance, as measured on the actual path, is presented in the next section.

3. PERFORMANCE

The complex nature of the video signal requires that performance be characterized by a number of parameters that provide an objective (quantitative) measure of the deleterious effects of the non-ideal (real world) transmission system.

The imperfections result from the addition of noise and interference, or crosstalk, to the desired signal as well as a multiplicity of distortions, which may be linear or nonlinear.

The performance of the two-for-one video terrestrial system has been characterized by a series of measurements of the video parameters. While measurements were performed on one of the two-for-one terrestrial radio channels, a color bar test signal was simultaneously carried over the other channel. The color bar test signal is considered to have strong interference potential.

Since the terrestrial system is used to convey video signals to the earth station for transmission via satellite, the performance of the terrestrial channel in tandem with the satellite system was also measured. For these tests, two different transponders (20 and 24 on RCA Americom's F1 Satellite located at 135° W) were accessed using up and downlinks at the earth station at Vernon Valley. The results of the measurements are that the perobjectives recommended by the Network Transmission Committee (NTC) of the Video Transmission Engineering Advisory Committee are met. In fact a more stringent broadcast quality objective was attained and that excellent quality video signals were provided. For these tests, the peak frequency deviation due to the video signal was 4 MHz, the frequency separation between video carriers was 16 MHz, and the i-f filters in the receivers at Hamburg each had a bandwidth of 16 MHz.

After the objective tests were completed, some time was spent in subjective tests. Observations of the programs transmitted over a two-for-one video channel and (for comparison) a conventional video channel over the terrestrial link were made. The pictures were of excellent quality with no marked viewer preference for one over the other. The video distortion measurements showed that performance of the two-for-one terrestrial link by itself and in tandem with the satellite link should be acceptable.

As part of the subjective evaluation, two unlocked color bar test signals were used as sources for the two-for-one video terrestrial microwave links. No discernible crosstalk effects were noted. Actually, by viewing the monitor, it was not possible to ascertain whether the adjacent channel was carrying modulation.

4. SIGNAL-TO-NOISE CONSIDERATIONS

Some consideration is now given to the effects of noise and specifically how the nature of terrestrial propagation affects system performance. Specific results for the New York City to Vernon Valley terrestrial microwave link will be shown.

The major problem on terrestrial microwave links is fading. Fading over these links has two basic origins. The first is multipath propagation which causes a reduction in signal strength due to interference between signals arriving at the receiver from different paths. The second major cause of fading is attenuation due to rain. For links using 6-GHz frequencies, the fading is dominated by multipath considerations. For 11-GHz links, the deep fades (occurring rarely) are caused by rain attenuation while the less severe, but more frequent, fades occur because of multipath.

The calculations presented here make use of the propagation results presented by Vigants[1] and Lin[2] of Bell Laboratories as well as storm models and rainfall statistics.[3,4] The results of the prior work have been applied to RCA Americom's New York to Vernon Valley terrestrial microwave link. The relative performance between a two-for-one and a conventional channel may be readily ascertained, although the absolute accuracy of the fading distribution is of course dependent on the quality of the propagation statistics utilized.

The performance for three different systems is presented in Table 1. The first system is the two-for-one system as implemented while the second system is the same equipment configured as for a conventional implementation (no combiner in New York, no backoff at the repeaters, and one divider deleted at Hamburg). Since the previous transmitting antenna at New York City had a lower gain than the transmitting antenna currently being used, the performance calculations were repeated to show what the performance of a conventional system would have been.

The results indicate that during the bulk of the time the terrestrial link will provide greater than 60 dB signal-to-noise ratio and that only for a small fraction of time (totaling less than one hour per year) will the signal to noise fall below that value. The difference in performance over the terrestrial link between the two-for-one and one-for-one systems is about 7 dB at .999 availability. However, had the one-for-one system been implemented with the previous transmitting antenna, there would be only a 4-dB difference in performance at the .9999 availability. It should be noted that at this high degree of availability, the deep fades are of extremely short duration (typically around 4 seconds) and the subjective effect on a video signal would be extremely difficult to discern.

Table 1 - Performance of Video over Microwave Channel (New York to Vernon Valley

System	Availability .99	.999	.9999
Two-for-One, present antenna	60 dB	60 dB	49.5 dB
Single Video, present antenna	60 dB	60 dB	57.0 dB
Single Video, previous antenna	60 dB	60 dB	54.0 dB

Note: (1) Frequency deviation due to video is 4 MHz in all cases. (2) Present antenna in New York City has gain of 44.7 dB. The previous antenna had a gain of 41.3 dB.

Since the signals are conveyed over the microwave link for the purpose of re-transmission via satellite, the end user sees the effects of the satellite link in tandem with the terrestrial link. In most cases, this performance will be completely dominated by the satellite link and not the terrestrial link. This was verified by calculating the signal-to-noise ratio expected for the space segment with the uplink at Vernon Valley and the downlink at various sites across the country. The earth stations at most of these sites were assumed to be typical of those installed for the cable television industry (with a G/T of approximately 21 dB/k).

As shown in Table 2 the space segment generally provides lower signal-to-noise ratios than the terrestrial link andperformance is indeed dominated by the space link. If a two-for-one terrestrial channel were substituted for a single video (conventional) channel, the end user viewing the combined space and terrestrial effects would not see any difference.

This was also verified in subjective tests carried out at Vernon Valley which has a much better space segment performance than the CATV earth stations.

Table 2 Video Signal-to-Noise Space Segment Only*

Receive Site	G/T	Availability .99	.999	.9999
Starke, FL	21	46.9 dB	46.8 dB	46.0 dB
Starke, FL	28	53.0 dB	52.9 dB	51.6 dB
Spruce, NC	21	49.0 dB	48.9 dB	48.3 dB
Vernon Valley, NJ	21	49.2 dB	49.1 dB	48.5 dB
Vernon Valley, NJ	32	58.1 dB	58.0 dB	55.6 dB
Houston, TX	21	48.1 dB	48.0 dB	47.5 dB
San Jose, CA	21	46.8 dB	46.7 dB	46.2 dB

*Uplink at Vernon Valley, Transponder 24, F2

5. AUDIO TRANSMISSION

The initial emphasis in establishing the viability of the two-for-one video transmission system has been on conveying the video information. Associated with every video program of course is an audio channel and it is equally important to convey this audio information in a manner which preserves excellent performance in a reliable manner. A number of techniques for the transmission of audio have been considered. Although the final decision as to which technique will be utilized has not been made, all of the four techniques presented here will provide excellent performance in an operational environment.

The first technique considered is to simply add the audio via a standard program channel frequency modulated subcarrier located just above the video baseband. This is, of course, the same way that the audio is carried on the single video channels. The advantage of this method is that since video and audio are carried over the same radio, it is simple from an operational standpoint. The disadvantage of this approach is that in order to keep the two channels constrained to the same bandwidth as previously required, it will be necessary to reduce the deviation due to the video to compensate for the increased baseband necessitated by the audio subcarrier. This will decrease the video signal-to-noise performance. It is estimated that a reduction of between 1.5 to 2.5 dB in video signal-to-noise may result. This will still provide excellent performance.

Other techniques considered convey the audio over a different microwave radio. There are several variations.

The current terrestrial microwave system between New York and Vernon Valley has basically two types of microwave radio traffic. One is video and the second is message. The standard video (one-for-one) is capable of carrying up to four audio channels using the frequency modulated subcarrier approach. Therefore, if the microwave system contains a mixture of two-for-one and one-for-one video channels, some or all of the audio channels may be carried on the one-for-one video radios.

If the audio capacity of the one-for-one video channels proves inadequate, then the capacity could be increased by utilizing a recently developed digital technique called Digital Audio for Television (DATE).[5] This technique which conveys four high quality audio channels on a single subcarrier when used in conjunction with an additional frequency modulated subcarrier, could extend the capacity of the single video channels to five audio channels.

Even if the video requirements dictate that all video channels be converted to two-for-one operation, thereby precluding the above one-for-one techniques from being implemented, it is still possible to provide excellent audio performance. This may be accomplished by using the message radio. A single group (of twelve telephone type channels occupying 48-kHz bandwidth) may be replaced by one or two 15-kHz program audio channels using currently available (off the shelf) equipment.

To summarize, the audio associated with the video may be conveyed either in the same microwave radio or a separate radio. Each approach has its own consideration but it is clear that excellent audio performance may be obtained. In our tests with the two-for-one video system, the audio was carried in a separate radio over one of the one-for-one video channels.

6. CONCLUSIONS

A system for transmitting two video programs within the frequency allocation assigned to a single video channel has been installed and tested over the New York City to Vernon Valley terrestrial microwave link. The system is such that the transmissions use the same total power as the single video channel. The performance has been excellent as confirmed by extensive objective and subjective observations for both signal-to-noise and video distortion effects. In the system tests, the audio has been conveyed via a frequency modulated subcarrier over another terrestrial video channel.

ACKNOWLEDGMENTS

Many people from both RCA Americom and RCA Laboratories have cooperated or assisted in bringing the system to its current state. Many of the initial discussions with Liston Abbott, Harold Staras, Richard Klensch, and Dan Walters were helpful in formulating some of the system considerations. The availability calculations were carried out using information and techniques suggested by Harold Staras. Many of the video modulation parameters were confirmed or determined experimentally by Richard Klensch, assisted by Kevin Kelley and David Zarodnansky. The installation and checkout of the microwave radios was carried out with the cooperation of Frank DeMille and the testing of the system over the microwave link and also the satellite received the significant assistance and cooperation from Frank DeMille, Bob Berntzen, Bob Kalb, Jim Easton, and Jack Brodersen.

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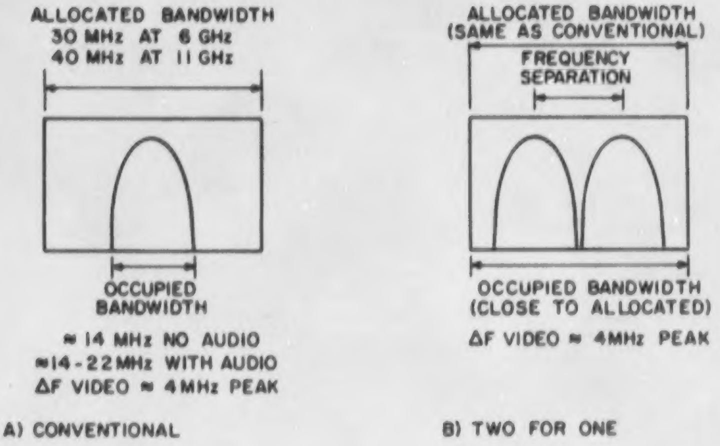
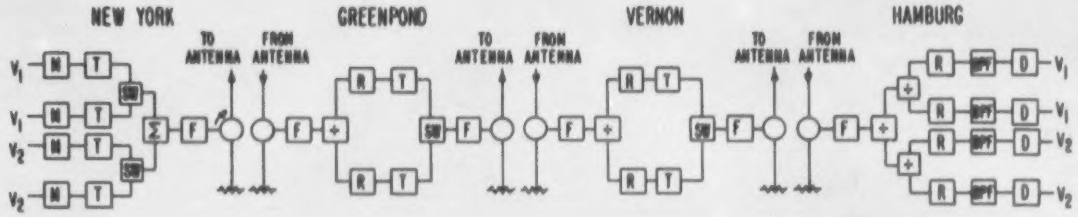

ALLOCATED BANDWIDTH
30 MHz AT 6 GHz
40 MHz AT 11 GHz
OCCUPIED
BANDWIDTH
≈ 14 MHz NO AUDIO
≈14-22 MHz WITH AUDIO
ΔF VIDEO ≈ 4 MHz PEAK
ALLOCATED BANDWIDTH
(SAME AS CONVENTIONAL)
FREQUENCY
SEPARATION
OCCUPIED BANDWIDTH
(CLOSE TO ALLOCATED)
ΔF VIDEO ≈ 4MHz PEAK

A) CONVENTIONAL

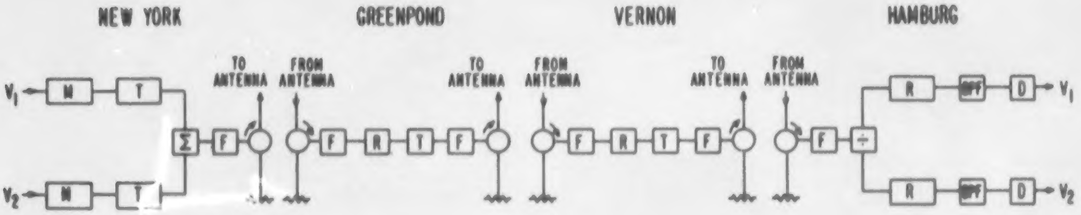
B) TWO FOR ONE

Figure 1. Bandwidth Considerations.


NEW YORK
GREENPOND
VERNON
HAMBURG
TO ANTENNA
FROM ANTENNA
V1
V2
M
T
SW
Σ
F
R
÷
BPF
D

SW - SWITCH FOR HOT STANDBY PROTECTION

Figure 2. Two Video Signals Single Terrestrial Channel, Basic System-Unprotected.


NEW YORK
GREENPOND
VERNON
HAMBURG
TO ANTENNA
FROM ANTENNA
V1
V2
M
T
Σ
F
R
÷
BPF
D

M - FREQUENCY MODULATOR
T - TRANSMITTER
Σ - COMBINER
F - RF FILTER, PART OF BRANCHING NETWORK, BAND PASS FILTER CENTERED ON ALLOCATED FREQUENCY BAND
○ - CIRCULATOR - PART OF BRANCHING NETWORK
BPF - BAND PASS FILTER AT IF TO ELIMINATE UNWANTED CARRIER
D - FREQUENCY DEMODULATOR

Figure 3. Two Video Signals in Single Terrestrial Channel, Operational System-Fully Protected.

AN ADVANCED DISPLAY TELEPHONE

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ABSTRACT

The display telephone is a small display terminal which can be used to obtain interactive personal services over the telephone lines such as telephone number directory assistance, electronic banking and videotext. The advantages include less use of paper and more up-to-date information.

A feasibility demonstrator has been constructed using a color CRT display and programmed for directory assistance. It features interactive data input by use of a transparent touch panel overlaying the display, instead of a more conventional keyboard.

1. INTRODUCTION

The "coming information age" is a term being currently used with the implication that access to and control of information will be of mounting importance in the next decade. Several information retrieval protocols and field trials, for access to remote databases via telephone lines, have been set up around the world; British Viewdata, French Antiope, Canadian Telidon, etc. The usual approach is to utilize the home television for display of data by providing an interface box between it and the telephone line. If there proves to be a demand for these and other services, it is likely that there will also be a demand for a display device other than the home entertainment television set. The display telephone is conceived as such a device.

The display telephone is a small, personal display terminal associated with the telephone, roughly the size of a typewritten page. It would be used by a single person rather than a group of people, which means the display size could be less than that of a full-sized television set. The display telephone would hopefully fit comfortably on a desk at home or in an office, increasing its utility for the services envisaged for it. These services include not only videotex information retrieval, but directory assistance, electronic banking, electronic mail, etc. All of these services involve interaction with a remotely located database computer, interaction that may be quite casual and not occur too often.

One of the motivations for a display telephone is to reduce the paper flow into the house or place of business. The usual paper telephone directory will be replaced by the display telephone and access to an electronic directory. Not only is the use of paper eliminated, but the directory service is kept up-to-date on a daily basis. No more having errors in the telephone book that last until next year.

Similar advantages accrue for electronic banking. Now, the first-class mail system is dominated by bills-to-be-paid, bank checks to pay them, and cancelled checks/statements. Electronic banking would use instead a central computer where the bills for each person would be stored electronically. The subscriber would view those bills on the display telephone and decide which to pay and when. The past history and present bank balance of the subscriber could be referenced on the same screen. Any bill that the subscriber wished to dispute would be left on display while a telephone call was placed to the billing office to discuss its details. Figure 1 is a block diagram of this situation showing the simultaneous operation of both services using two lines.

Paper bank statements and cancelled checks would be replaced by electronically stored equivalents; i.e., a public key cryptography system would be used to transmit such information to a local memory of the subscriber. In this manner the subscribers have such evidence under their control. Having provided this local memory and display for the subscribers, it could be used for many other personal records with the same advantages of compact storage and instant access.

A display telephone demonstration unit was built to further study the nature of the interaction process. In addition, variations on the traditional keyboard input-CRT output scenario have been tried. Specifically, the keyboard on the display telephone has been replaced by a transparent touch sensor overlaying the display that is used for all input.

This demonstrator is one of a series of devices built at GTE Laboratories to investigate the application of digital technology to the subscribers local loop. One other notable example is the data/digital telephone for simultaneous duplex transmission of voice, data and keying signals.(1) In this situation only one telephone line will be needed instead of two as shown in Figure 2.

2. DISPLAY TELEPHONE CONCEPT

The investigation of the display telephone concept was broken down into two related tasks, one directed at the hardware possibilities of building the display phone, and the second directed at the software in the interaction process. The two tasks are related in that the hardware selected for the input technique has a strong bearing on the software interactions possible.

2.1 Hardware

2.1.1 Input Techniques

Input from a keyboard is the traditional means of communicating from a terminal. A first version of the display telephone had a keyboard with special function keys labelled for one major application; directory assistance operation. It soon became obvious that the display telephone would be easier to use in every individual application if it had special application keys. This has been attempted in the past with card overlays. A better solution would seem to be one that allowed the "keys" to be relabelled by the far-end computer, because the "keyboard" is put on the display and data entry is directly associated, possibly by touching on the display screen. A light pen is suitable for this purpose, but fear of reliability problems during general use in the home caused it to be rejected. Instead, a transparent sensor (overlaying the display) that responds to a finger or pen touch was selected. The selection of a "key" is directly tied to the display, no looking down at a separate mechanical keyboard.

This method has several additional benefits. Besides allowing "keys" (boxes on the screen) to be relabelled, it allows narrowing of input choices at each stage to only those that are valid, and provides the flexibility needed when it is not exactly certain what the uses of the display telephone will be over the lifetime of the instrument. For example, because of security problems, the introduction of electronic banking may be delayed and another service, such as electronic shopping, may take its place. The terminal must have the flexibility to adapt to uncertain features and applications. Another benefit of touch input which we have found is that people not familiar with computer terminals are cautious about hitting keys on a keyboard, but do not mind pointing to their choice.

There is a limit to touch input, however. Alphabetical typing is done with a projected typewriter keyboard on the screen. This is acceptable for limited input, i.e., spelling a name for directory assistance, entering a password, etc. However, for general continuous input such as is needed in electronic mail, touching the keyboard soon becomes tedious. For example, putting "copy" into the system will be much faster with touch typing on a mechanical keyboard.

Speech recognition is another possibility which would allow more "natural" input to the display telephone. Speaker trained, single utterance speech recognition of limited vocabularies (100 words) is now becoming widely available. For telephone use, however, speaker independent recognition is necessary as a practical matter, especially if the recognition equipment is located at the database computer. Speaker trained recognition techniques may be extended to quasi-speaker independent recognition through the use of clustering techniques in the recognition domain.(2) Templates (the stored representations, in frequency or time, against which the unknown utterance is compared) from multiple speakers can be grouped, according to some orthogonality criterion, so that a random talker will properly match one of the clustered words and be recognized. Recognition rates of 90 percent using this technique may be considered acceptable for interactive data retrieval. Unfortunately the 90 percent recognition is on each single utterance, so that for an application of dialing a seven-digit number, the machine accuracy is reduced to (0.9) to the seventh power, or less than 50 percent. To insure 90 percent recognition of a seven-digit number, each number must be recognized to better than 98.5 percent accuracy, an extremely difficult task for random callers.

2.1.2 Output Techniques

In general, the output of the display telephone will require the display of a page of text. This may be extended to limited graphics in the case of weather maps, touch-screen keyboard, etc. Keeping with the size goals of the telephone (fits on a desk), a flat-panel display would be most desired. In the long run the display technique might include the touch-sensing as part of its multiplex structure. In the near term, there is no flat substitute (in terms of cost) for a CRT when displaying alphanumerics and limited graphics. In addition, a CRT technique permits the use of color. Arguments against color include cost considerations and the fact that most of the world's printed matter is black-and-white. Arguments for color include the fact that its careful use in display text make an interactive program much easier to use. Commands are more easily highlighted and separated from previously entered data.

An important design constraint is to have a combination of transmission rate and display detail such that most changes in the display occur in roughly one second or less. For example, with present mosaic videotex display standards (an alphabet of 128 characters displayed on roughly 20 rows and 40 columns) the standard incoming transmission rate of 1200 b/s is barely fast enough. Even an order of magnitude increase in speed (19.2 kb/s) can be argued as being beneficial. In the future, use of increased resolution (geometric or photographic modes of videotex) will aggravate this problem.

2.2 Software

The ease of interaction with the user will ultimately determine the acceptance of many of the display telephone services. Aside from the input and output techniques in hardware, the interaction is largely determined by the software. The terminal is intended for non-computer oriented people, who may use the telephone only occasionally, once every day or less. This argues for a menu-driven process. At each step a limited number of choices are presented which eventually home in on the desired data. In addition, the screen echos back the path taken so far and at least two "escape" keys are provided: One which goes back one step (to change input or correct errors), and one which returns to the start of the current process. To accommodate the frequent user, it is desirable to include a means of skipping forward to the answer (where possible) if the user knows from the start where it is located.

The menu-selection process blends well with the touch-input technique. The correct choice of the menu is touched at each step. For example, the first menu allows a choice of services. It appears to allow a smoother flow than determining the correct choice, looking across to its number, looking down at the keyboard and pressing the number. As stated previously, the limitation on touch input is when more than a few words must be typed In the future, a display telephone may combine the use of keyboard, touch and speech inputs.

It cannot be overemphasized that the entire design of the display telephone, especially the software program and CRT graphics concentrated on presenting a friendly interface to the human user. Worded differently this meant writing a fool-proof program that anticipated the subscriber questions, kept the user informed of what was in process and used obvious self-correcting feedback on all data entries.

3. DISPLAY TELEPHONE DEMONSTRATOR AND EXPERIMENTOR

In order to explore some of the concepts outlined above, experimental hardware and software was assembled at GTE Laboratories. To eliminate the problem of maintaining a database, directory assistance was chosen as the demonstration service. Automated directory assistance has the advantage of being a self-contained telephone company problem. In certain areas telephone number databases are already kept on computer for directory assistance operators, and by providing interface software in the display telephone which looks to the computer like a trained operator and looks to the user like a friendly service, it is possible to experiment with one display telephone service.

The hardware was assembled to work with regular available telephone lines that would be used in practice. A 1200-baud modem and automatic dialer provide connection with the directory assistance computer when the user touches (selects) this service entry in the initial menu. An S-100 based microcomputer runs the software which leads the user through the assistance request steps, formats the input, and passes the information to the computer. The computer responds with the telephone numbers which match the request and the microprocessor echos these to the display. It then handles any follow-up requests, i.e., page forward, page back, dial the requested number, etc.

The demonstrator uses a 13-inch color CRT Intecolor terminal and an Elographics transparent overlay for touch sensing. This touch panel is one of several types and was selected for its' simplicity of construction and associated electronics. Basically this touch panel system periodically outputs the position of anything (finger, pen, etc) touching the screen.

In the present demonstrator the software program has been arranged to recognize where this touching point is located relative to a series of displayed "touch" blocks. In this sense it is a discrete touch panel. But by using other software, the actual position can be tracked. In the future it is intended to use this property to allow "signatures" on letters (or "bank checks"?). An inherently discrete touch panel array would not be able to handle signatures or drawings.

As presently implemented, the directory assistance service is accessing the databank provided by an IBM 411 information operator (I/O) assistance system. The display telephone service builds on that offered by the I/O assistance system to offer the "friendly" interface needed by the untrained subscriber. Several GTE telephone operating companies are presently using such I/O assistance systems.

4. CONCLUSIONS

A display telephone for subscribers has been conceived, suitable for personal interactive services using remote computer databases. A feasibility demonstrator has been constructed that is programmed for telephone number directory service. The remote computer database is that actually used by information operators in handling subscriber inquiries. It features a color CRT display overlayed by a transparent touch panel for interactive data input. The subscriber merely touches his choice of data input using either a menu selection technique or display "keyboard". Emphasis has been placed on designing a friendly terminal whose software program and CRT graphics are tailored to the human user.

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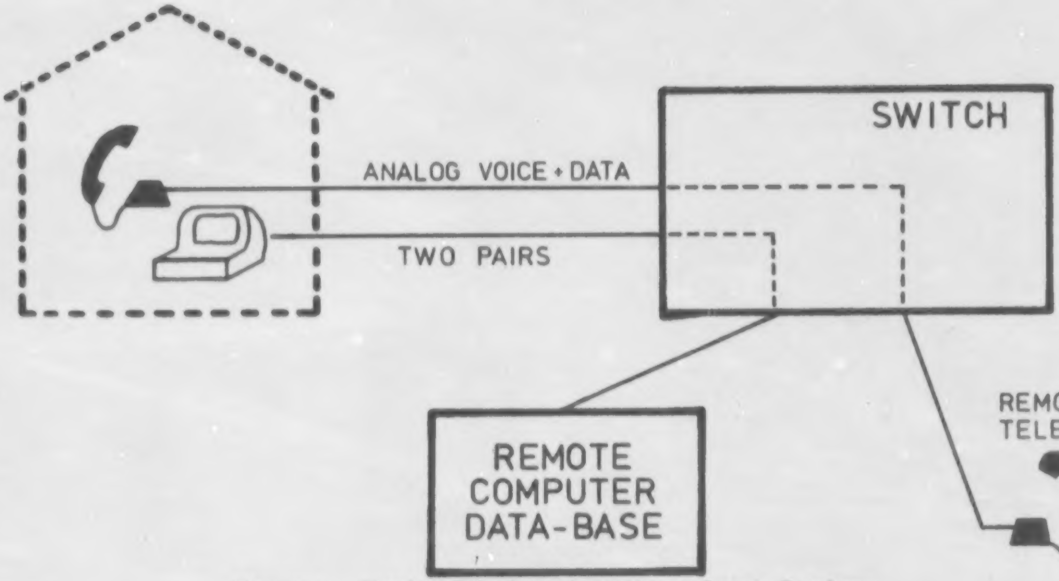
SWITCH
ANALOG VOICE + DATA
TWO PAIRS
REMOTE COMPUTER DATA-BASE
REMOTE TELEPHONE

Figure 1 - Display Telephone Accessing a Remote Database While Regular Telephone Service is Maintained

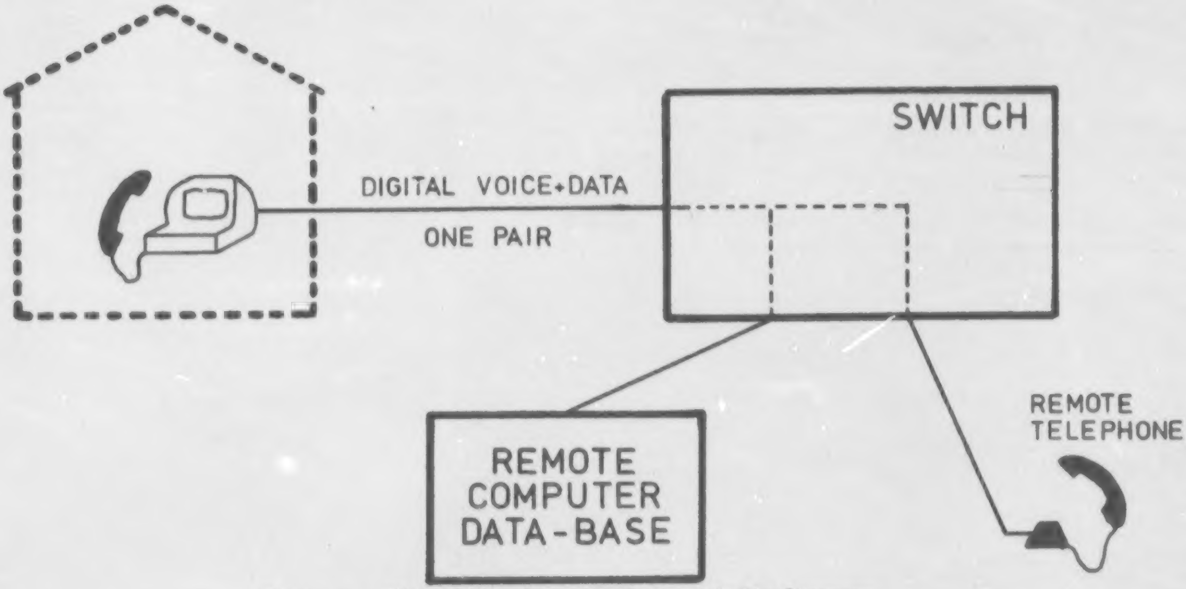
SWITCH
DIGITAL VOICE+DATA
ONE PAIR
REMOTE COMPUTER DATA-BASE
REMOTE TELEPHONE

Figure 2 - Digital Display Telephone with Simultaneous Voice and Data Capabilities

120 Mbps TDMA Terminal Equipment

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Abstract

This paper discusses the main features and design of the Common TDMA Terminal Equipment which is to be used to determine the most effective TDMA system in the INTELSAT-V and succeeding satellite systems. Some of the more important techniques used in implementing these design concepts are described and performance results are presented. The description encompasses the QPSK modem, the Burst MUX/DUX and the TDMA burst synchronization functions. The synchronization hardware includes the Preamble generator, the Unique word detector, the Burst synchronizer and the Automatic entry unit.

1. INTRODUCTION

The PCM TDMA system is now under planning for being incorporated into the INTELSAT-V and succeeding satellite systems which are to use the 14/11 GHz band, the spot beam with or without the on board satellite switch matrix and with orthogonal polarization. This paper presents the 120 Mbps common TDMA terminal equipment which has newly been developed as a part of TDMA TEST BED(1) and which is to be used to determine the most effective TDMA system in the new environments as mentioned above.

The terminal equipment can be adapted to a number of subsystems depending on the new technologies which are considered to be effective in the future environments. And the terminal equipment is now used to demonstrate the performance of the new technologies such as:

- High speed forward error correction (FEC),
- Space diversity switching,
- Absolute phase modulation,
- New acquisition technique (pulsed CW method(2)).

The terminal equipment can also be used to investigate the optimum system parameters in the future environments. The major parameters to be investigated are as follows.

- The narrowband filter bandwidths of both the carrier and the bit timing recovery circuits,
- Length of the carrier and the bit timing recovery sequence,
- Unique word (UW) pattern for both the reference and the data bursts,
- UW detection rule for the data burst.

The development of the 120 Mbps common TDMA terminal equipment has been completed, and the objective performance has been demonstrated as a test result The hardware of the terminal equipment comes in three units for use at three separate earth stations; i.e., the Main Local Station, the Monitoring Station and the Reference Station. Photo 1 shows the exterior view of these units. By using these three units, both loopback and feedback mode tests can be carried out. The functional block diagram of a unit to be installed in the Main Local Station is shown in Fig.1. The sections below give more detailed descriptions of the respective blocks shown in Fig.1.

2. DESCRIPTION

2.1 MODEM

The block diagram and the major performance requirement of the modem are shown in Fig.2 and Table 1.

On the modulator side, the two burst data streams are filtered by the transmit lowpass filters (TX LPF), yielding Nyquist waveforms with 30% roll-off spectral shape. Then, they quadruphase modulates the gated burst carrier, yielding a QPSK modulated signal which enters the bandpass filter to reject spurious of the modulated signal.

On the demodulator side, the received 140 MHz modulated burst signal, after passing through the receive bandpass filter, is first injected to the slow acting AGC circuit, which normalizes the peak level of the received signal, and then it is divided into three paths; one is fed to the carrier recovery circuit, another to the bit timing recovery circuit, and the last one to the coherent phase detector. The recovered carrier facilitates coherent detection of the received modulated signal at the coherent

Table 1. Major performance of modem.

Modulation	Four-phase PSK
Bit rate	120.064 Mbps (60.032 Msymbols/s)
Transmit spectrum	30% cosine roll-off
IF frequency	140 MHz
Demodulation	Coherent detection
Operation mode	Burst mode
Interburst interference	Burst-to-burst level level difference of 3 dB max. Guard time of 2 symbols min.
Bit error rate	$<5\times10^{-3}$ after 40 symbols for $E/N_0 = 7.3$ dB $<1\times10^{-4}$ after 40 symbols for $E/N_0 = 10.6$ dB $<1\times10^{-6}$ between 40 - 70 symbols for $E/N_0 = 14.6$ dB $<1\times10^{-7}$ average in data part of the burst for $E/N_0 = 14.6$ dB
Unique word error rate	$<1\times10^{-8}$ at BER $= 1\times10^{-2}$

This paper is based upon work performed under the sponsorship of the International Telecommunication Satellite Organization (INTELSAT). Views expressed in this paper are not necessarily those of INTELSAT.

detector. Then, the two received data output are regenerated at the decision circuits by using the recovered bit timing signal.

The TX LPF provided for spectrum shaping of the transmit signal, consists of a lowpass filter section, an amplitude equalizer section and a delay equalizer section. The lowpass filter section is realized by modifying the zeros and poles of the transfer function of a 7th order elliptic function filter. The amplitude equalizer section is necessary to provide $x/\sin x$ amplitude characteristics and consists of only a few components. The delay equalizer section consists of one first order and two second order allpass networks. Photo 2 shows the transmit eye pattern at the output port of the TX LPF.

Fig.3 shows the block diagram of the carrier recovery circuit. It regenerates the carrier component by frequency quadrupling and one-by-four frequency dividing. Extraction of the carrier component from noise is made by using a single-tuned tank circuit with AFC. Selection of the bandwidth of the tank is important because the phase error of the recovered carrier depends on it. Computer simulation showed that the external Q value of 40 is the optimum. Photo 3 shows the transient receive eye pattern.

A square-law detector is used to regenerate the bit timing component. Extraction of the bit timing component from noise is carried out by using a single-tuned tank circuit. There are two tank circuits corresponding to the bit timing signals for the decision circuit and for the baseband system. The Q values employed are 70 for the former signal and 130 for the latter signal.

Fig.4 shows the overall BER performance of the newly developed modem in both steady and transient states.

The tanks for both the carrier and the bit timing recovery circuits are made replaceable. This facilitates the tests for determination of the optimum parameters of the modem for variety of conditions of the transmission link.

2.2 MULTIPLEXER AND DEMULTIPLEXER UNIT

The Multiplexer and the Demultiplexer Unit (MUX/DUX) generate and distribute the timing control signals to the Terrestrial Interface Modules (TIMs) and the Preamble Generator (PGU). The MUX/DUX route the subburst data from/to the TIMs and to/from the common TDMA terminal equipment at appropriate time. Also, the MUX provides the control signals for uplink selection and carrier on/off switching for the modulator. Scrambling and descrambling are accomplished by these units themselves. All the timing control signals above mentioned are generated by a unit whose basic circuit configuration is as shown in Fig.5. The unit has a memory which contains a program that defines the sequence of symbol time slot references or events for all the gating pulses furnished by the unit. Burst events are stored in and read out of the memory in the linear sequence in which they occur. The contents of the memory output register are compared with the contents of a time slot counter. When the event code and the time slot count coincide, an event pulse is generated. A staring matrix controlled by the function code routes the event pulse to the appropriate interface. An event pulse makes the memory address counter count up by 1 so that the next event word is shifted to the memory output register.

The MUX and the DUX are each divided in two parts as shown in Fig.6 to conform to various types of FEC codec. Each part has the same basic configuration, which is shown in Fig.5, as that of the other. There is a certain difference in phase between the contents of the two time-slot counters in both parts. The difference in phase is determined by a variable delay circuit whose delay time corresponds to the coding/decoding delay of the FEC codec applied. The delay time ranging from 0 to 255 symbols is accepted. The memory employed is a type of field programmable ROM. PROM appears to be suitable for meeting the nonvolatile and the ease-of-programming requirements. Memory address region that is actually accessed is determined by the contents of the switch register in Fig.5. That is, the selection of the program applied from among a number of programs contained in the memory can be carried out by manual operation of the switch register.

Scrambling and Descrambling

Scrambling and descrambling sequences are generated by 15 stage feedback shift registers. The generating polynomial is $x^{15} + x + 1$. On the transmit side, the starting contents of the shift register for scrambling is provided by a manually operated switch register. The contents are moved to the shift register prior to each start. Thus, the same starting contents of the shift register are applied to the transmission of each burst. On the receive side, the starting contents of the shift register for descrambling are provided by the memory which is used also to store the event codes. This is to make the terminal equipment to conform to multiple receiving bursts which have the different starting contents.

2.3 PREAMBLE GENERATOR UNIT

The Preamble Generator Unit (PGU) functions to:

- ° Generate the carrier and the bit timing recovery sequence and the UW sequence, which are parts of the preamble.
- ° Combine the transmit traffic data and the preamble and send the comined bit stream to the QPSK modulator.
- ° Encode the combined bit stream differentially before sending it to the QPSK modulator (When DCPSK transmission is intended).

The preamble of a burst consists of the four parts, i.e., the carrier and the bit timing recovery sequence, the UW swquence, the voice and the telegraphy orderwire sequence and the station identification code and status sequences. Each part is generated by the corresponding unit and combined by the PGU. The contents of the carrier and the bit timing recovery sequence are readily alterable in segments of 4 symbols. The length of this sequence can range from 30 to 127 symbols. For the UW sequence, an arbitrary pattern of sequence in length of 10 to 24 symbols can be applied. These functions facilitate performance tests of the various modulation systems under the various conditions of transmission links.

A modified UW pattern is used along with the normal one The modified UW is transmitted periodically in place of the normal one to perform super-framing for transmission of the control signalling channel sequence and the telegraphy orderwire channel sequence. The modification is performed by:

- ° Logically inverting the original UW sequence bit by bit. This sequence is applied when the DCPSK modulation is engaged.
- ° Interchanging the two partial sequences of the UW which are transmitted through two parallel channels of quadruphase modulation transmission. This modification is applied when absolute phase modulation is engaged.

2.4 BURST SYNCHRONIZER UNIT

The Burst Synchronizer Unit (BSU) is required to control the time of burst transmission such that the burst overlap does not occur at the satellite. The BSU provides a timing control signal called the Transmit Frame Reference (FRM REF X). If a burst is supposedly transmitted at the time when the FRM REF X occurs, the burst and the reference burst shall coincide in time at the satellite. The actual burst transmit time is determined by the MUX based on FRM REF X.

The functional block diagram of the BSU is shown in Fig 7 The BSU can be divided functionally into two parts, i.e., the frame counter and the sync error measuring circuit. The sync error measuring circuit is used only when the loopback mode of operation is engaged. In this mode, an earth station is able to receive its own transmitted burst through the satellite. In the feedback mode, its own transmitted burst is not available to receive through the satellite. So, the sync error measurement is asked to the associated earth station. Hereafter, the operation of the BSU in loopback mode is explained first.

In Fig.7, the reference UW detection pulse is gated to begin the count operation of the delay counter. When the contents of the delay counter reach the predetermined value, a pulse called delayed reference pulse is developed. In the same frame, the local UW detection pulse is selected and compared in time with the arrival of the delayed reference pulse. Because the position of the local burst with respect to the reference burst is known and the delay counter is so programmed, the two pulses arrive simultaneously, when the local burst is in the correct frame position. If the two pulses arrive at different time, the magnitude and the polarity of the difference are meausred and stored in units of symbols by the error storage counter. The error data is fed to the decoder which decides whether the error is zero or not. The output of the decoder controls the counting period of the frame counter, whose specified contents are detected to create FRM REF X. The frame counter has a counting period of 45024 or 45024 ± 1 symbols. As to which one of the period is to be taken, this is determined by the control signal fed by the decoder.

The period is normally 45024. When nonzero error in the error storage counter is recognized, the period of 45023 or 45025 is used depending on the polarity of the error. At the same time, the count down of the contents of the error storage counter is carried out.

The phase error measurement and correction occur once every 300 msec. This is dictated by the round trip delay to the satellite, since a new error measurement may not be made until the previous correction has been made.

When the feedback mode of operation is to be performed, the error is fed to the error counter by the Monitoring Station through the control signalling channel. The correction method is the same as that used in case of loopback mode except that the error correction period is 600 msec.

For acquisition operation, a mechanism to read out and preset the contents of the frame counter at the refernce UW detection timing is provided. The contents of the frame counter are moved to/from the Control Logic Unit.

2.5 AUTO ENTRY UNIT

Once an earth station transmits a burst, the proper transmit time can be known by comparing the reception time of this burst and that of the reference burst. However, if the station has been off the air, there is no reliable information to give a sufficiently precise start-of-burst time. The Auto Entry Unit (AEU) is to define the time of transmission for the BSU so that the stations initial transmitted data burst will arrive at the satellite within the allotted time slot without interfering with the burst transmissions from other stations. The AEU generates a modulated IF transmission whose level is low compared with the normal data transmission level. This power level is low enough to ensure that no unacceptable interference to data bursts occur even if the acquisition transmission overlaps to bursts from other stations. Two AEU systems based on different techniques are provided. Each of these systems can be selected by manual operation of a switch located on the Control Panel.

PN Method

Fig.8 shows the functional block diagram of the PN modulation AEU. The PN generator provides a PN sequence whose period is equal to that of the TDMA frame. The PN sequence generated is synchronized to FRM REF X. The output of the PN generator is gated by PN/CW and then fed to the two phase PSK modulator. At the modulator, the locally generated carrier, whose frequency is offset 10.612 MHz from the TDMA IF frequency, is two phase-modulated by the PN sequence. The modulated signal is fed to the transmit IF switch. The switch is controlled by the Transmit Acquisition Window. Thus, under the control of PN/CW and Transmit Acquisition Window, a 0.9 sec unmodulated carrier and the following 1.8 sec PN modulated signal are yielded at the output port of the transmit IF switch in the acquisition window. The output of the switch is level adjusted by the attenuator, and, on having its spurious rejected by the BPF, is taken out through the buffer amplifier.

On the receive side, the frequency control of the local oscillator (LO) is performed by using the former 0.5 sec unmodulated carrier in the incoming signal. The remaining 0.4 sec unmodulated carrier portion is allotted to AGC. The received carrier is frequency converted in the mixer by using the outout of the LO whose frequency is swept across a ±50 kHz range from its normal frequency. The output of the mixer is bandlimited by the BPF and then led to the AGC amplifier. A specified LO frequency which provides the maximum AGC voltage during frequency sweeping is memorized and is used as the LO frequency throughout the acquisition process in the acquisition window. The output of the AGC amplifier is changed to a baseband PN sequence by the delay detector. The correlator compares the recovered PN sequence with the locally generated one whose clock rate is offset from its nominal value. When the correlator recognizes good correlation between them, the offset is removed and then the DLL controls the phase of the locally generated PN sequence to coincide with that of the recovered one. When all the procedure explained above is completed, the specified content of the local PN generating shift register is detected by the decoder whereby the phase detection pulse is yielded. The time difference between the occurence of the phase detection pulse and that of Receive Frame Reference (FRM REF R) is measured by the error counter, and the sync error is thus provided. The basic parameters of the PN AEU are given in Table 2.

Table 2. Performance of PN auto-entry unit

(Transmit side)	
Modulation	Two-phase PSK
Bit rate	170.66 kbps
IF frequency	: 129.388 MHz ± 1 kHz
Acquisition signal	: CW(0.9s) and PN-modulated carrier(1.8745s). PN generating polynomial is x^7+x+1
(Receive side)	
IF frequency	: 129.388 MHz ± 50 kHz
Demodulation	: Differential detection
Correlation	: Baseband correlation by delay lock loop with swept local PN generator
Probability of success to acquire :	99.9% (in 5 minutes)

Pulsed CW Method

The pulsed CW AEU transmits the successive swept acquisition pulses of CW within the assigned acquisition window. The acquisition pulse is generated at the rate of one pulse per frame, delayed by 16 symbols per frame to sweep across a frame. On the receive side, the AEU watches to see whether the acquisition pulse going through the satellite enters the normal burst position of the station attempting the initial acquisition or not. When the received pulse is detected within the normal burst position, the normal time to be transmitted is decided by the detected time at the receiver. The functional block diagram is shown in Fig.9.

On the transmit side, the ACQ pulse generator generates an acquisition pulse (ACQ pulse) such as a wide pulse of 3 msec width and narrow pulses of 6.2 µsec width in the acquisition window. The ACQ pulse generated is synchronized to Local Burst Transmit Timing which is provided by the MUX based on FRM REF X. The generated timing chart of the ACQ pulse is shown in Fig.10. The ACQ pulse gates a carrier whose frequency is offset 10.612 MHz from the TDMA IF carrier frequency. The gated carrier is level-adjusted by the attenuator, and, on having its supurious rejected by the BPF, is taken out through the buffer amplifier.

On the receive side, the incoming signal is fed to the mixer where the frequency is converted to 10.7 MHz band. The output of the mixer is bandlimited by the BPF and is level-controlled by the AGC in the Receive side Acquisition Window. The output of the AGC amplifier is changed to baseband pulses by the envelope detector. The integrator, which accepts the recovered baseband pulse, discriminates the wide pulses from the narrow pulses. The decision circuits for wide and narrow pulses decide if the corresponding pulses occur also in the receiving aperture. The error counter is fed by the output of the decision circuits and counts the number of TDMA frames which exist in the period ranging from the end time of the wide pulse to the detection time of the narrow pulse. Because the transmitted ACQ pulse is arranged as shown in Fig.10, the transmission timing error E is given by $E = 16 \times M$ (symbols) where M is the count of the error counter, and the receiving aperture is generated at the local burst receive time. The basic performance of the Pulsed CW AEU is as shown in Table 3.

Table 3. Performance of pulsed-CW auto-entry unit

(Transmit side)	
Modulation	: on/off keying
IF frequency	: 129.388 MHz ± 1 kHz
Acquisition signal :	wide pulse.... 3 ms narrow pulse.. 6.2 µs sweep rate.... 16 symbols/frame
(Receive side)	
IF frequency	: 129.388 MHz ± 50 kHz
Demodulation	: envelope detection
Pulse detection:	wide pulse.... 4 successive detection after integration during 8 µs narrow pulse.. 14 out of 20 majority decision
Probability of success to acquire:	99.9% (in 5 minutes)

2.6 LOCAL CLOCK GENERATOR

The local terminal clock is needed for the time base of the synchronization control of the whole terminal system, and it is generated by the Local Clock Generator. The frequency stability of the local clock is needed to be good enough to keep the local burst transmission timing error within the guard time during the whole process of reference station transfer. During the process, no reference burst is provided and it lasts up to three seconds. The local clock is generated by a high pricision crystal oscillator which is phase-locked to the recovered clock of the received reference burst. To ensure high stability of the symbol clock frequency, the Local Clock Generator has two precision voltage controlled crystal oscillators, one for the operation and the other for its back-up. And also the unit is backed up by batteries just in case of primary power failure. The major performance of the Local Clock Generator is shown in Table 4

Table 4 Performance of local clock generator

Frequency	: 60.032MHz ± 1 part in 10^7
Short term stability	: $<1\times10^{-9}$ per second
Frequency adjustable range	: ±50 Hz
Long term stability	: $\leq 1\times10^{-8}$ per day
Pull-in range	: 60.032 MHz ± 6 Hz

2.7 UNIQUE WORD DETECOR UNIT

The Unique Word Detector consists of the reference UW detection circuit, the data UW detection circuit, the differential decoder for use when DCPSK transmission is engaged, the phase ambiguity resolution circuit for use when absolute phase modulation transmission is engaged, the retiming circuit and the aperture generator circuit.

UW Detection Circuit

The UW is used for the purpose of burst synchronization, super framing and phase ambiguity resolution of recovered carrier in case of absolute phase modulated transmission. To meet these requirements, the UW detection circuit has an 8-fold UW detection capability. Two UW detection circuits are provided corresponding to the reference and the data UWs. To cope with bit errors in the received UW sequence, some protection system is provided.
A system engaged for the reference UW detector is to indicate that a sync lock or a sync loss has occurred, when 5 consecutive complete reference UW sequences are detected or when no complete UW sequences are detected in 5 contiguous TDMA frames. For the data UW detector, a system which allows up to a specified number of bit errors (ε) in received UW sequence is engaged. Both the detectors for the reference and the data UWs can handle an arbitrary UW pattern of 10 to 24 symbol length.
The functional block diagram of the data UW detector is as shown in Fig.11. The incoming two parallel p and q channel data are fed to the two shift registers The contents of the shift registers are compared bit by bit by the EXNOR array with the contents of switch registers P and Q. The switch register contains the UW pattern for which the search is to be made. An exclusive NOR circuit which recognizes that the output of the shift register coincides with the output of the switch register porvides a logical '1' at its output port. The output of the EXNOR array is fed to the full adder array. The full adder array yields a binary coded number which corresponds to the number of the '1' which is provided by the EXNOR array. The outputs of the full adder array are combined by four adder/subtractors to provide four binary coded numbers. These numbers correspond to the numbers of the shift register output bits which coincide with the bits of the eight different UW patterns. The output of the adder/subtractor is threshold-decided by the digital comparator to provide the eight different UW detection pulses.

Aperture Generator

An aperture generator is to ensure reliable UW detection. The aperture generator forces the UW detection circuit to operate only in a short period in which UW detection is presumed. The other functions of the aperture generator are to reset the retiming ciucuit and to porvide the downlink selection signal.

Two aperture generators are used. One is for use with the reference burst, and the other with the data burst. The reference aperture generator has a delay counter whose delay time corresponds to one TDMA frame period. When a reference UW is detected, the delay counter provides a five-symbol width pulse centered at one TDMA frame's delayed position from the detection time. The pulse is used as the signal to predict the detection time of the next reference UW. The data aperture generator has a frame counter which is reset and restarted at the time of the reference UW detection. By using this counter like the time slot counter in the MUX /DUX, seven-symbol width pulses are generated centering at the predicted time of UW detections.

Retiming Circuit

The retiming circuit synchronizes the recovered data with the local symbol clock. For the conversion, recovered data is once stored in a memory under the control of the recovered clock and the read out of the memory under the control of the local clock. Fig.12 shows the functional block diagram of the retiming circuit. The recovered data is written in symbols one by one in the memory. The write address is specified by the write address counter which counts up its contents on receiving the recovered clock pulse. The data stored in the memory is read out from the address which is specified by the read address counter. The read-out address counter counts up its contents on receiving of the local clock pulse. The circuit is good enough in performance to allow the frequency difference of up to 2×10^{-5} between the recovered and the local clocks.

2.8 CONTROL SIGNALLING UNIT

The control signalling unit provides a cammunication channel to control and monitor the TDMA network operation. This channel performs :

- ° Sync data feedback in both acquisition and steady states.
- ° Transmission of UW lost and bit error rate

detection statuses.
- Voice orderwire signalling.

In order to provide error control for this signalling channel, coding for error detection only and repetitive four-time transmission are used. The generator polynomial used for generating the 13-bit parity check is:

$$g(x) = 1 + x^4 + x^7 + x^{11} + x^{12} + x^{13}$$

The control signalling unit performs the coding and decoding for the error control and the format arrangement for transmission of signalling sequence. The unit consists of Intel's SBC 80/10 board computer, the dedicated interface board and the associated computer program. The size of the program, except for the resident 80/10 monitor program, is 1.5 kBytes.

2.9 ORDERWIRE UNIT

Two kinds of orderwire sequences are provided; one is for voice orderwire service and the other is for telegraph orderwire service. However, only one voice orderwire channel equipment is equipped.

A voice orderwire channel which is not in use for voice orderwire service is also used for BER measurement in the TDMA network. A specified fixed code pattern is continuously transmitted through a voice orderwire channel which is not in use for voise orderwire service. The fixed pattern is recovered on the receive side, and then compared with the locally generated replica of the fixed pattern. The BER measurements thus obtained are digitally displayed continuously on the Display Panel. The measurements are also stored in the BER memory. The stored BER data is available externally on demand. When BER measurements exceed 10^{-4}, which is the operation threshold, an alarm is actuated.

2.10 CONTROL LOGIC UNIT

The control logic unit performs the following controls of the overall terminal system.

- The sequence control of the terminal in the start-up or the shut-down status.
- The status control of the terminal to have it adapt itself to varying environment conditions.
- The controls of the terminal in the acquisition status to have it conform to the acquisition protocol.

The control logic unit consists of Intel's SBC 80/20 board computer together with the SBC 519 I/O expansion board, the dedicated interface board and the associated computer program. The size of the program, except the resident 80/20 monitor program, is 1.5 kBytes. The main memory of the control logic unit has battery to protect its contained synchronization data from accidental loss through a possible power failure.

3. CONCLUSION

The CTTE for the Main Local Station of TDMA TEST BED described in this paper has been built, installed and tested along with the CTTEs for the Reference Station and the Monitoring Station. The performance characteristics of all CTTEs meet all the specifications. The equipment is expected to be used effectively for determination of the most effective TDMA system to be designed for the future international satellite communication networks.

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(1) "System Specification of the INTELSAT Prototype TDMA System," INTELSAT Document, BG-1-18 (Rev.2), March 1974.
(2) H.Kurihara, A.Ogawa and Y.Hirata,"A New Initial Acquisition Technique for PCM-TDMA Satellite Communication System," Third International Conference on Digital Satellite Communications, November 1975.

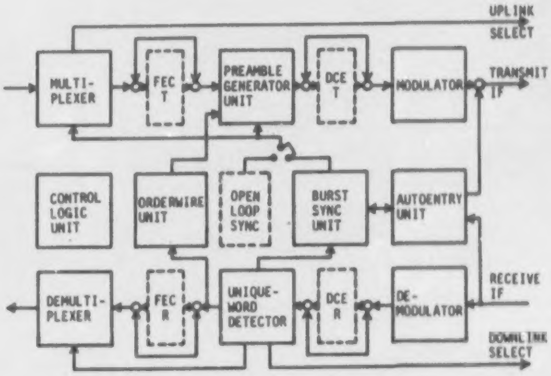

UPLINK SELECT
MULTI-PLEXER
FEC T
PREAMBLE GENERATOR UNIT
DCE T
MODULATOR
TRANSMIT IF
CONTROL LOGIC UNIT
ORDERWIRE UNIT
OPEN LOOP SYNC
BURST SYNC UNIT
AUTOENTRY UNIT
DEMULTI-PLEXER
FEC R
UNIQUE-WORD DETECTOR
DCE R
DE-MODULATOR
RECEIVE IF
DOWNLINK SELECT

Fig.1 Functional Block Diagram of CTTE

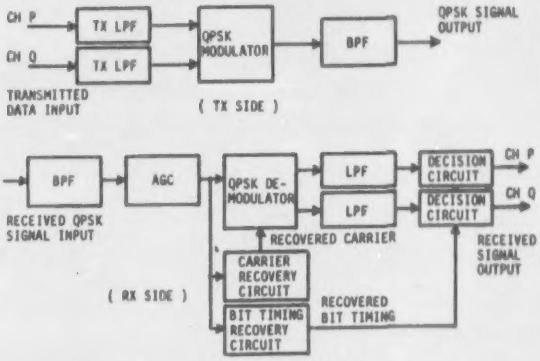
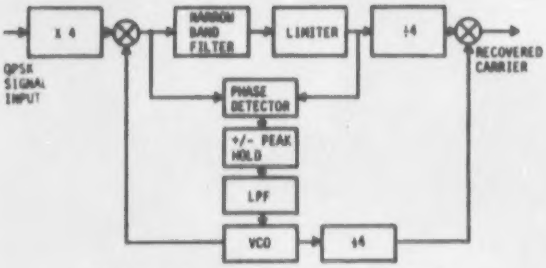

CH P
CH Q
TX LPF
TX LPF
QPSK MODULATOR
BPF
QPSK SIGNAL OUTPUT
TRANSMITTED DATA INPUT
(TX SIDE)
BPF
AGC
QPSK DE-MODULATOR
LPF
LPF
DECISION CIRCUIT
DECISION CIRCUIT
CH P
CH Q
RECEIVED QPSK SIGNAL INPUT
RECOVERED CARRIER
CARRIER RECOVERY CIRCUIT
RECEIVED SIGNAL OUTPUT
(RX SIDE)
BIT TIMING RECOVERY CIRCUIT
RECOVERED BIT TIMING

Fig.2 QPSK MODEM Block Diagram



X 4
NARROW BAND FILTER
LIMITER
÷4
RECOVERED CARRIER
QPSK SIGNAL INPUT
PHASE DETECTOR
+/- PEAK HOLD
LPF
VCO
÷4

Fig.3 Carrier Recovery Circuit

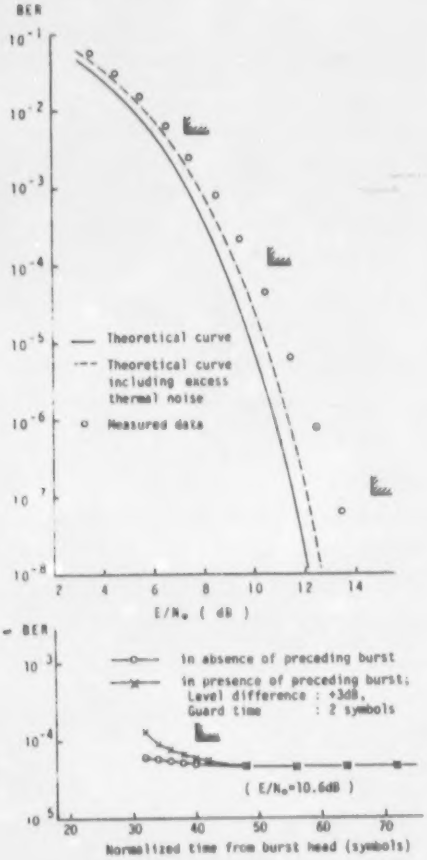
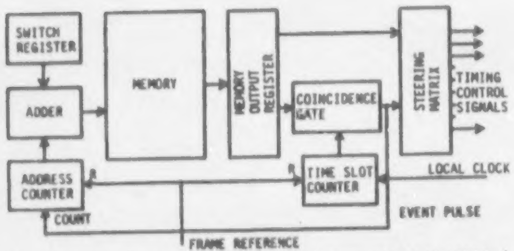
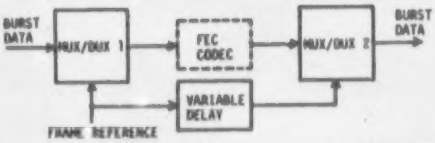


Fig.4 BER Performance of MODEM



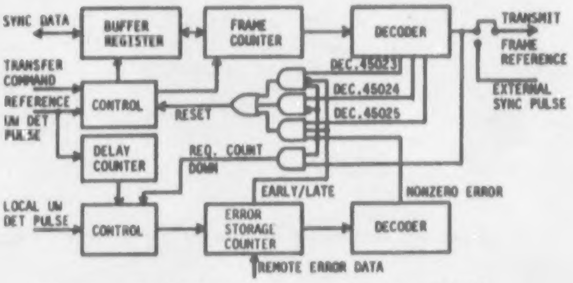
SWITCH REGISTER
ADDER
MEMORY
MEMORY OUTPUT REGISTER
COINCIDENCE GATE
STEERING MATRIX
TIMING CONTROL SIGNALS
ADDRESS COUNTER
R
R
TIME SLOT COUNTER
LOCAL CLOCK
EVENT PULSE
COUNT
FRAME REFERENCE

Fig.5 Basic Circuit Configuration of MUX/DUX (a)



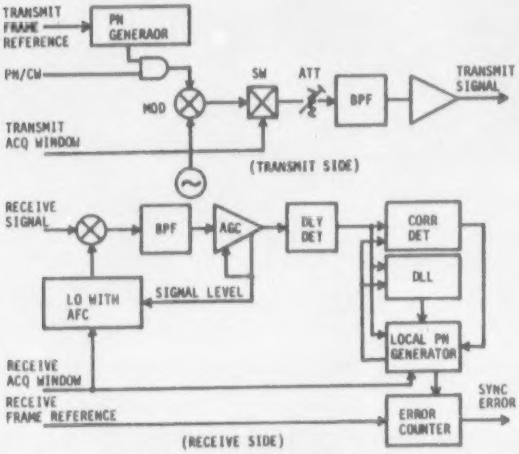
BURST DATA
MUX/DUX 1
FEC CODEC
MUX/DUX 2
BURST DATA
VARIABLE DELAY
FRAME REFERENCE

Fig.6 Basic Circuit Configuration of MUX/DUX (b)



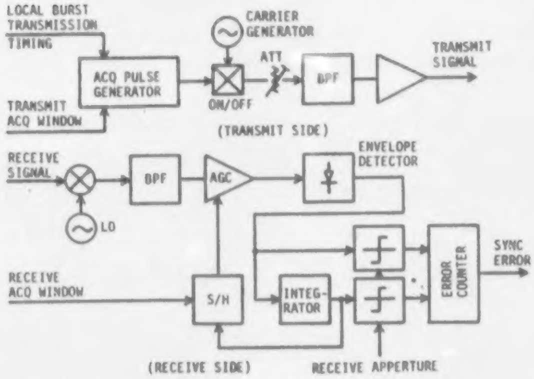
SYNC DATA
BUFFER REGISTER
FRAME COUNTER
DECODER
TRANSMIT FRAME REFERENCE
TRANSFER COMMAND
REFERENCE UW DET PULSE
CONTROL
RESET
DEC.45023
DEC.45024
DEC.45025
EXTERNAL SYNC PULSE
DELAY COUNTER
REQ. COUNT DOWN
EARLY/LATE
NONZERO ERROR
LOCAL UW DET PULSE
CONTROL
ERROR STORAGE COUNTER
DECODER
REMOTE ERROR DATA

Fig.7 Functional Block Diagram of BSU



TRANSMIT FRAME REFERENCE
PN GENERAOR
PN/CW
MOD
SW
ATT
BPF
TRANSMIT SIGNAL
TRANSMIT ACQ WINDOW
(TRANSMIT SIDE)
RECEIVE SIGNAL
BPF
AGC
DLY DET
CORR DET
DLL
SIGNAL LEVEL
LO WITH AFC
LOCAL PN GENERATOR
RECEIVE ACQ WINDOW
RECEIVE FRAME REFERENCE
SYNC ERROR
ERROR COUNTER
(RECEIVE SIDE)

Fig.8 Block Diagram of PN AEU



LOCAL BURST TRANSMISSION TIMING
CARRIER GENERATOR
ACQ PULSE GENERATOR
ATT
BPF
TRANSMIT SIGNAL
TRANSMIT ACQ WINDOW
ON/OFF
(TRANSMIT SIDE)
RECEIVE SIGNAL
BPF
AGC
ENVELOPE DETECTOR
LO
RECEIVE ACQ WINDOW
S/H
INTEG-RATOR
ERROR COUNTER
SYNC ERROR
(RECEIVE SIDE)
RECEIVE APPERTURE

Fig.9 Block Diagram of Pulsed CW AEU

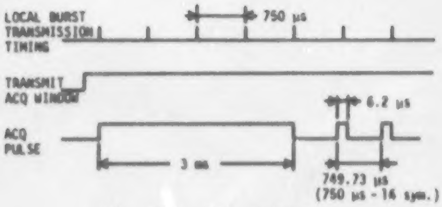

LOCAL BURST TRANSMISSION TIMING
750 µs
TRANSMIT ACQ WINDOW
6.2 µs
ACQ PULSE
3 ms
749.73 µs
(750 µs - 16 sym.)

Fig.10 ACQ Pulse

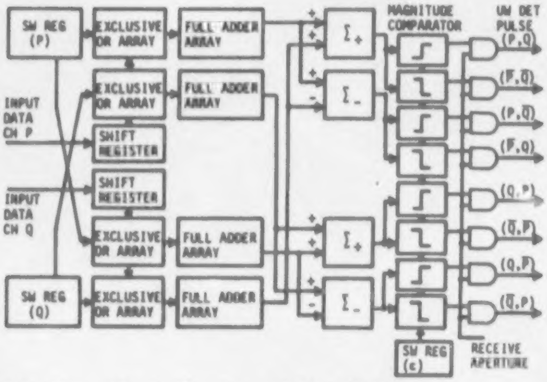

SW REG (P)
EXCLUSIVE OR ARRAY
FULL ADDER ARRAY
INPUT DATA CH P
SHIFT REGISTER
INPUT DATA CH Q
SW REG (Q)
Σ_+
Σ_-
MAGNITUDE COMPARATOR
UW DET PULSE
(P,Q)
$(\bar{P},\bar{Q})$
$(P,\bar{Q})$
$(\bar{P},Q)$
(Q,P)
$(\bar{Q},\bar{P})$
$(Q,\bar{P})$
$(\bar{Q},P)$
SW REG (c)
RECEIVE APERTURE

Fig.11 Block Diagram of Data UW Detector

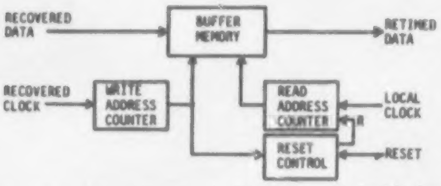

RECOVERED DATA
BUFFER MEMORY
RETIMED DATA
RECOVERED CLOCK
WRITE ADDRESS COUNTER
READ ADDRESS COUNTER
LOCAL CLOCK
R
RESET CONTROL
RESET

Fig.12 Functional Block Diagram of Retiming Buffer

CTTE for Main Local Station

CTTE for Monitoring Station

CTTE for Reference Station

Photo 1 Exterior View of CTTEs

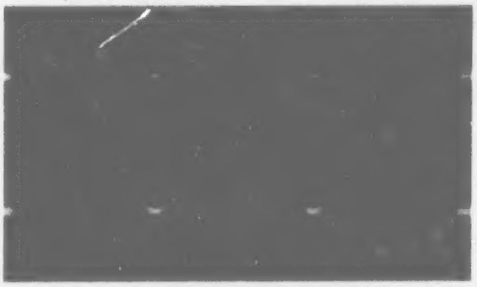
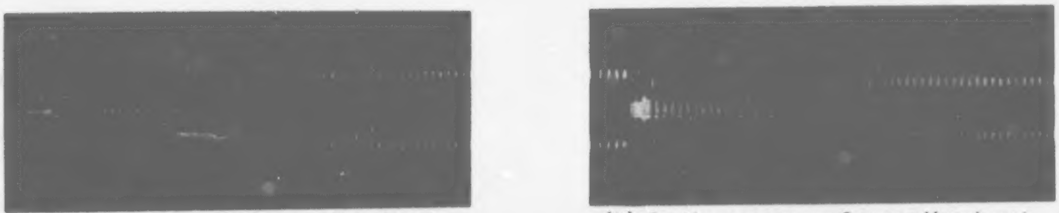


Photo 2 Transmitted Eye Pattern



(a) In the absence of preceding burst

(b) In the presence of preceding burst

Photo 3 Transient Received Eye Pattern

COMMUNICATION AND TECHNOLOGY TRANSFER

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Abstract

An examination of the process of technology transfer--linking a resource with a need--requires a consideration of the answer to at least two questions: how is the selection made of technology to be transferred? and how is this transfer of technological innovation done appropriately? This paper will examine the variables affecting the choice and the match of communication technology transfer both among and within countries of Asia and the Pacific.

> "We lost the light, and our hearts do not beat faster.
> We are silent." . . . V. Trehan, 1980.
>
> ". . . the cow in the picture book does not eat grass."
> . . . K. E. Eapen, 1979.

These two comments on the SITE experiment in India illustrate the dichotomy in the arguments surrounding the issue of technology transfer. An examination of the process of technology transfer --linking a resource with a need--requires a consideration of the answer to at least two questions: how is the selection made of the technology to be transferred? and how is this transfer of technological innovation done appropriately? This paper will examine the variables affecting the choice and the matching of communication technology transfer both among and within the countries of Asia and the Pacific.

Definition of Terms

Communication is defined as mutual understanding, mutual purpose, mutual control, a shift from the "doing unto" model in which information was transferred and people were persuaded to do something, to a "doing with" model in which information is shared and people participate in decisions (King, 1980).

Technology can be described as software or hardware, referring not merely to "hard" machinery and technical skills, but to training programs, organizations, management and other "soft" technology (King, April 1979). "Technology is not and cannot be abstracted from the situation in which it is to be used; it is the direct link connecting needs to organized and rationalized means of satisfying these needs" (PASITAM, 1977). Technology transfer involves linking resources with needs (Bond, 1979) and needs with resources. It may be a direct application or there may be some reinvention--adaptation or tailoring of the technology to fit its new use or user (Gee, 1974).

Alternate technologies are those which "represent an alternative, or rather a complement, to the technologies which dominate the economic and social system in the industrialised countries and in the 'modern' sector of the developing countries" (Jequier, 1975). These alternate technologies include appropriate technology (AID, 1972; Goodman, 1976), intermediate technology (Schumacher, 1973), and soft technology (Mackillop, 1973)--terms which are used interchangeably in the literature. To Schumacher, the process of technology transfer must include an awareness of human values and the values of the system into which the transfer would be made. Schumacher (1973, 1979) believed in an intermediate technology--produced by the masses, compatible with ecology, cognizant of scarce resources, and conducive to decentralization. In all of this, we are concerned with consequences, the changes which occur within a social system as a result of the adoption or rejection of an innovation (Rogers and Shoemaker, 1971).

Variables Affecting Choice and Implementation of Technology

In an attempt to provide an answer to the two questions posed at the beginning of this study, variables affecting the choice and implementation of technology will be examined within the framework of the stages of the innovation process: problem-definition, search of alternative solutions, matching, diffusion/implementation, institutionalization (Rogers and Chen, 1980).

Problem-definition. There must be awareness on the part of all involved that a problem exists and that this problem has priority for action. The problem must be constituted as such by the people who are most involved--and so must the solution. If there is to be sharing and input into the decisions to be made, the process must begin with the problem definition. The problem can be as broad as narrowing the communication gap between industrial and developing nations in the Pacific (Glatzer, 1978), or narrowing the communication gap between villages in Papua New

Guinea (Korowi, 1980). The operational definition of the problem will determine what communication technology will be adopted as a solution.

Search of Alternative Solutions

The developing countries which are trying to determine and implement policies related to technology transfer are faced with several options (Jequier, 1975). The first is to try to halt the invasion of foreign technology, e.g., Papua New Guinea and the introduction of television (Korowi, 1980). The second is to leapfrog over the "normal" stages of economic and technological development by either massive transfers of modern technology from the industrialized countries, e.g., oil-producing countries (Jequier, 1975), or to move into the future directly, by-passing the whole stage of industrialism, transferring from a pre-industrial to a post-industrial society (Iyengar, 1972; Mead, 1975). The third option recognizes both the importance of technology transfer but also the inappropriateness of much of the technology from the developed countries, and attempts to strike a balance between what it is necessary to obtain from outside the area, to what can be developed locally--between technology transfer and appropriate low-cost or intermediate technology (Jequier, 1975; Schumacher, 1979). The growing concern with equality and a desire for the majority of the people to gain greater control over the environment (Rogers and Adhikarya, 1978) is countered by a desire for greater self-reliance nationally in sophisticated science and technology (Jussawalla, 1980). The third option is an attempt to provide more choices, keeping in mind both societal and individual aspirations and economic realities and facilitating the assessment of the impact of a given technology on cultural, social, political, and economic patterns (Gonod, 1975; Pool, 1973).

Matching. Will the innovation work to solve the "perceived problem" (Rogers and Chen, 1980)? "Is it economically feasible and otherwise adapted to the intended purpose and location?" (Lionberger, et. al., 1979). Can it be realistically implemented given--in the case of communication technology--available capital, consumer demand, adequate equipment, criteria for service?

> If technology transfer is geared to basic needs satisfaction for the periphery, then it has to be both problem-specific and location-specific. There can be no "technological fix" or a purely communication technology solution to the problems of poverty and underdevelopment in terms of economic opportunity and social mobility. Technical change is not a random phenomenon. It calls for a vital learning experience and an institutional and societal setting that will render the experience dynamic and worthwhile. (Jussawalla, 1980)

It is in this particular step in the innovation process that the intangibles of technology transfer (McGinn, 1978) operate. It is the fall-out that becomes the problem--the decline in interpersonal communication because of the introduction of television into homes in Canton (Li, 1980); the adoption of TV dinners by Algonkian Indians in Canada (Granzberg and Steinbridge, 1980). These are unanticipated consequences for many but for some groups the consequences are anticipated and result in the non-adoption of the innovation because of a value taken or not taken into account when the innovation is first advanced. The Ministers in Sri Lanka knew that to concentrate on telecommunication needs would mean a decline in education, health, and other services which had a first priority with them--and so they waited until they felt the "match" could be made to introduce more advanced communication technology into the country. This wait, however, did not prohibit their sending planners and policy-makers to conferences at the East-West Center so that they would know what to do when the time came to do it.

Because of the diversity of individuals and systems, adoption of an innovation often means a modification or adaptation of the technology being transferred in order to get a better "fit" between the innovation being introduced and the user(s) and the problem(s). "Adopt, adapt, adept" is the reinvention process which can occur in technology transfer. Some people say that technology transfer does not occur without reinvention because of the diversity of individuals and systems. With hard technology this reinvention process may occur to take advantage of, or from, lack of resources. With soft technology this reinvention process is a certainty to occur to "match" more closely the individuals and the system into which it is being introduced.

Diffusion/Implementation. This is the stage in which the innovation is diffused throughout the system, both before and after changes have taken place within the structure of the innovation itself, and is adopted or rejected. In March 1980, Dr. Dvorkovitz & Associates who has the largest world-wide data base for licensing technology (King, November 1979), sponsored a symposium on technology transfer to developing countries as part of its 8th Annual World Fair for Technology Exchange in Singapore. The reports from several countries included recommendations for diffusion and implementation of technology.

The report from France emphasized among other things "needs, common sense, and basic instruments of millions of people" for the implementation of industrial products (France, 1980). The "musts" from Japan included skilled personnel capable of receiving technology transfer, management ability by executives, and a fit of the technology to meet the needs of markets and customers (Himi, 1980). From Singapore came the following suggestion; to establish facts regarding the following--

a. The infrastructure of the country as well as the company.
b. The financial resources of the company.
c. The type of supporting industries that were available in the country.
d. The technical skills available in general and those related to the type of operation proposed.
e. The market size.
f. The climatic conditions and the special features required in the product to meet consumer needs.

Then and only then can a phased program for implementation be developed (Sithawalla, 1980).

There are both formal ("procedures for dissemination of storage, indexing, and retrieval of knowledge") and informal ("interpersonal communications and contacts, personal beliefs and feelings about a knowledge source, perceptions . . .") factors which operate within the process of technology transfer (Jolly and Creighton, 1975). Probably the single most important factor within this model is the linker, the person(s), organization(s) or agency(ies) who link source and application.

All of these variables/factors are facilitated by the overall communication process or climate. If the process is one of mutuality of purpose then benefits will accrue for both (or all) parties involved, measure to measure. If the process is not one of sharing, participation, and mutual purposing, then the situation may occur in which one (or all) of the parties involved are using and/or being used. This latter situation does not necessarily lend itself to mutually accruing benefits.

Institutionalization. The innovation becomes routinized, standardized, and a regular part of the on-going operations of the adopters. The two experiments in communication technology which defy institutionalization are the SITE experiment approximately one year in duration which will be continued through landlines but to only a small number of the original villages, at least for some time yet (News Briefs, 1978; King, April 1979). And PEACESAT, Pan Pacific Education and Communication Experiments by Satellite, which at this point in time links together sixteen countries in the Pacific in an interactive system which permits two-way communication. It has been used for educational experiments (King and Sanderson, 1977; Kunimoto, 1971); for coping with an outbreak of dengue fever throughout the Pacific (Bystrom, 1980) and of Ross River fever in the Cook Islands (Sullivan, 1980); and for sharing recipes in order to improve nutrition in the Pacific (Krauss, 1980). But PEACESAT utilizes the ATS-1, and the satellite is some twelve years longer lived than anticipated. It is the prototype of what could be in interactive satellite communication between and within countries. At this point in the innovation process the innovation is no longer perceived as new because it has been integrated so fully into the everyday actions of the adopters.

Conclusions

Obviously there is a bias on my part--to have the formulation of policies and the planning for development of communication take place within a participatory paradigm. You may not agree with the value framework.

The determination of the innovation to be transferred is one made with as full and complete information as possible regarding resources, long-range and immediate goals and objectives for the country, and an assessment of the consequences--the changes that will take place because of the adoption or the rejection of the innovation. But however it is made, it must be made with the people who will be the consumers as well as the entrepreneurs; that is good business. And technology transfer is a business.

The determination of the appropriate mode of transfer is often inherent in the type of communication technology chosen. More often though it is not. When Minister Korowi states that he will put a telephone in every village in Papua New Guinea, he knows how that can be done; a lesser person might have said a telephone in every home.

The dichotomy illuminated in the two opening comments becomes more understandable--but nevertheless unacceptable. Only with a value shift, such as the one outlined in this paper, can the needs and desires of the developing world be realized.

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LINKING RESOURCES AND NEEDS:
SOME COMMENTS ON A SYSTEM AND ITS OPERATION

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Abstract

A better, more efficient utilization of existing technological resources is possible. This linking of resources and needs is necessary to increase our capacity to respond to future challenges. One organization is in operation solely to facilitate this linkage. This paper describes briefly the services offered by this organization and comments on its computerized technology licensing system.

There are pools of untapped resources lying dormant throughout the world. Yet at the same time, many needs are left unrealized with painful, often paralyzing consequences for humankind. Both old and new problems continue to confront us: notable are those of meeting the basic, life-sustaining requirements for our expanding population; encouraging informed, meaningful participation of societies in the decisions regarding profound technological responses to our increasing demands; and fostering an awareness of and concern for the ecological ramifications of our choices.

But where are these resources? How can we access them? And how do we promote their development and commercialization in the interest of serving humankind and contributing to our increased capacity to meet the needs of the future? In other words, how can we optimize the linking of resources and needs?

This paper sketches one response to this dilemma, the response by an organization with but one purpose--the collecting of available technology from all possible sources and seeing that it is disseminated to those who are in a position to utilize the technology, somewhere and somehow. This international organization is Dr. Dvorkovitz and Associates (DDA) which was founded in 1960.

DDA was conceived as a technology licensing service which could facilitate the search for existing technology, to avoid duplication, to allow for greater coverage and to do it in such a way that the results (the resources) could be made available to all companies, governments, or others regardless of their size or location. The service is supported through the use of the world's largest repository of technology available for licensing. This bank is computerized for ready access and includes all types of technology except military hardware and computer software.

Ormond Beach, Florida, is the site of the central computer; the system works to bring German products onto the market in Japan, Swedish products onto the market in Singapore, Hong Kong products into France, and so on, as well as U.S. products overseas and products from all other countries onto the U.S. market. Hundreds of developments have been licensed through DDA and the number expands at an increasing rate each year.

On-line access to the technology bank is presently available in approximately 30 countries (the expansion of the network continues) via Telenet. However, DDA representatives are located in more than 40 countries and service many more.

While the quantity of items in the bank has grown at a rapid rate, it has purposely been limited to minimize the inclusion of valueless patents and other "trivia." A continuous review is made and items are regularly deleted if they are found to have become obsolete, or the item is licensed, etc. DDA deletes more items than most organizations ever acquire, and deliberately refrains from including news items, technical information or names of companies seeking technology with their requirements.

The "data" in the bank are tailored to the requirements of a successful technology transaction. Of course, a descriptive title and abstract are included. A description of the main use or application and the main advantages (a comparison with existing technology) is also listed. Similarly important is the information on the status of the technology: that is, its degree of commercialization (plans only, lab or prototype, pilot production, full production), availability of economic data and know-how, type of license offered, patent protection (pending or awarded, by country), and any special requirements such as secrecy agreements.

It should be emphasized that the DDA technology bank includes technology for which patents have been applied, and which in many cases would not be found in any published literature. It also includes technology based on "know-how" which would not be found in published sources. It is therefore not just a duplicate of other data bases, but a unique source that is without comparison. Even if an item of technology may be found in other data bases, they do not contain the vital additional information such as why it is significant or better than others, how far it has been developed, and whether it is available for license.

DDA is a licensing service of a comprehensive nature, that has been compelled to utilize computer capabilities to manage the information available. It is a total service, providing additional data, samples, assistance, etc., including all costs of time on the computer--unlimited in a search mode--on a continuing basis, with the opportunity to search many different subjects at many different times so that the client can increase his/her likelihood of success.

What about the cost of service? DDA does not charge the licensor when it accepts the technology for exposure through the service. There is also no charge to the licensor for insertion, storage or for the continuing efforts to license the technology, regardless of whether these efforts are successful or not. The fees are earned from the side of the licensee. DDA must satisfy these clients who purchase the service. Thus, DDA must maintain a data base of technology that is extensive enough, significant enough and relevant enough, to meet the requirements of its clients. If a submission of technology does not meet these requirements, it is rejected. All other data bases are built either on the fact of mere publication elsewhere, or the willingness of someone to pay for the "advertisement" of their technology.

This aspect of the service has beneficial implications for those companies/countries which do not have the financial resources to compete with others when "selling" their technologies. All technology, regardless of the source, has world-wide exposure. Likewise, the process of searching for technology needed by a company/country is greatly facilitated and is comparatively less expensive than methods that rely exclusively on individual or unsystematic efforts.

In this way also, a company/country in search of technology is presented with the widest possible range of available technology. Their subsequent decisions can then be made with an awareness of the numerous alternatives. Only with this awareness can one make informed, responsible technological choices.

I mentioned earlier that the service was supported by a computerized technology bank. The bank does just that, and no more. Any transfer or transaction of technology ultimately rests on an exchange between people. No computer system can replace the dynamics of this personal exchange. DDA recognizes this and for the past 8 years has sponsored the "Tech Ex World Fairs for Technology Exchange." These annual events have grown into a 3 site (North America, Europe and Asia), 3 week opportunity for people to come together to buy and sell technology from all over the world.

Tech Ex is not "just a Trade Show," or an ordinary "fair," but an event attended by business executives from a high level within their organizations working seriously and in a down-to-earth way at the business of licensing, joint ventures and technical services. Tech Ex is not a place to collect brochures. It is a place to work, where the action is on the floor. Discussions leading to license agreements, joint ventures, technical service agreements, etc., go on from dawn to dusk at the stands between the inventors/licensors, and the potential developers/licensees. Often these meetings continue on through the night at their hotel suites.

Tech Ex is the answer to the question, "where can I go in search of new technology to cover the most territory, in the shortest possible time, at the least cost?" Tech Ex is also the answer to the question, "where is the best established market place for technology I have to sell?"

Tech Ex '81 will again be held at 3 sites: Atlanta (U.S.) March 10-13, Vienna (Austria) March 17-20, and Colombo (Sri Lanka) April 29- May 4.

The Colombo Fair is being cosponsored by the Government of Sri Lanka. This unique exhibition of technology particularly suited for the needs of the developing countries will also incorporate all the aspects of a major Trade Fair. Capital equipment will be displayed and demonstrated for Civil Engineering projects, Hospital and Health Care facilities, and Agricultural Development. Products and Processes for new industry, increased employment opportunities, improved living conditions, health and nutrition will be explored.

Concurrent with the Fair in Sri Lanka, a congress on technology transfer and the developing nations will be held. "Self-reliance and the sharing of experiences" is the theme of the congress. Speakers will cover both positive and negative experiences in depth. The areas for discussion include:

1. Training, Infrastructure, Skilled Labor & Management
2. Urban Development, Housing, Sanitation, Civil Engineering
3. Water Management, Agriculture, Food Preservation
4. Solar Energy
5. Remote Sensing, Resource Evaluation
6. Telecommunications

In summary, technology transfer is a process--a process rooted in personal exchange and experience; a process that can be facilitated with computerized systems now available and in operation; and a process, that if successful in making a more efficient use of existing technology currently lying dormant throughout the world, could improve our ability to respond to new and existing challenges and affect the very nature of our existence.

Communications Technology and National Development
--A Third World Perspective

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Abstract

Communication is the lifeblood of society. Therefore, if the countries of the Third World are to develop rapidly and secure a better life for the citizens, it is indeed imperative that the communication systems prevalent in these countries be made more efficacious. This, obviously, involves the introduction of new communications technology. The introduction of new communications technology is closely related to a number of social, economic and cultural factors which have clear policy implication. In my paper, I wish to examine these problems, which are common to most Third World countries, within the larger framework of national development policy.

A few years ago, I was visiting a remote part of Sri Lanka cut off from the tide of urban activity. There I saw a middle-aged farmer ploughing his field with a buffalo, while a transistor radio discreetly placed on a mound nearby was blaring a popular film song. This image remains vividly in my memory. Last year, I was walking along a narrow street in Colombo in the evening, and I saw a crowd of over fifty people gathered outside a boutique watching an American television show with rapt attention. This image, too, remains vividly in my memory. These two images, it seems to me, convey a very powerful message. That is, communication technologies, whether we like it or not, are increasingly impinging on the fabric of social life and the collective consciousness of the people of the developing world. Communication technology is unquestionably here to stay. Therefore, instead of harking back to a bygone golden age of idyllic pastoral beauty as indeed some nostalgically do, the communicationists and the policy makers in the developing world would be well advised to address their minds to the question as to how best they could utilize the new communication technologies and control them in their arduous task of social development.

By communication technology, I mean radio, printing technology, television, satellites, computers as well as low-cost video equipment and cassettes. Communication technology can be harnessed both for constructive and destructive purposes. It all depends on how they are pressed into service, and the goals and objectives that activate their use. As we scan the recent history and the experience of many of the Third World countries, it becomes manifest that these technologies have the potentiality for both good and ill. The crucial determinant is the social vision which motivates their use. This is indeed an important dimension in view of the fact that some would go so far as to insist that technology itself is the message.

Communication technology, if used wisely, can facilitate social development as no other instrumentality can. In modern times, for any society to make progress, the citizenry should be able to have access to more and more information in an increasingly quicker time. After all, when we examine the evolution of communication media in human society, we realize that it parallels the increasing accessibility to more information with greater speed. This is indeed an important consideration in view of the fact that with the acquisition of more information, the generality of the public will be in a better position to place the contemporary experiences of their own societies in a wider and therefore more meaningful global framework, and arrive at more informed judgments regarding the day to day management of their own societies. In the modern world countries are closely interlinked as never before; an event, a trend in one part of the world is bound to have repercussions on other parts of the world. That is why I say that the wider the framework of analysis, the more informed and meaningful the judgment is likely to be. The new communication technology help enormously in processing and distributing ever larger quantities of information with increasing speed. Therefore, it is quite evident that for any culture in modern society to develop communication technology should play a very crucial role indeed.

However, things are not as simple as one would like them to be. There are a number of obstacles to which we should pay more than cursory attention. One is that if the generality of the public is to make us of the new communication technology for constructive developmental purposes as perceived by the people, it is imperative that they should have full access to the communication media. Unfortunately, the institutional structures and the power relationships obtaining in many of the Third World countries stand in the way of achievement of these objectives. Instead, the new communication technologies are deployed in a manner that will result in only fortifying and legitimizing the power of those who are in control of society. Hence, if the statement that the new communication media help to promote social development is to rise above mere rhetoric, it is indeed vital that all those who are genuinely concerned with development in the Third World should address this issue.

Along with the need to have free access to information via the new communication technologies should be stressed the importance of disseminating the right kind of information. Quite obviously, some kinds of information are more relevant to the needs of the people of the Third World and can act as stimulants in the march towards progress. Other kinds of information can have the exactly opposite effect. Therefore, the policy makers in the developing countries will have to exercise a great sense of discrimination in selecting the relevant from the irrelevant, assuming, of course, that the selection is a prerogative of them and not a decision foisted on them from without. At the same time, the policy makers in the Third World should guard against the temptation to indulge in a form of blatant censorship under the guise of discriminatory selection, which, in the end, will only be to their detriment.

Another danger to which we should be alert is the propensity to make use of new communication technologies as instruments of mind management and cultural and ideological domination. Basically this can operate at two levels--the international and the national. At the international level, those who control the new communication technologies could use them as tools of mind management and cultural and ideological domination of weaker societies. Similarly, the wielders of power at the national level could use them for identical purposes. One can, also, I suppose, conceive of this occurring at the subnational level as is evidenced by the influence of Oahu on the other Hawaiian islands in the sphere of communication. One need hardly add that this is in the long run, counter-productive.

When we seek to devise more efficacious and productive strategies for the deployment of modern communications technologies for the purpose of social development we need to pay attention to six important dimensions. They are:

1. Economic
2. Political
3. Social
4. Cultural
5. Technical
6. Institutional

When examining the economic dimension we need to ask such questions as: Do the developing countries have the economic power to invest usefully in new communication technology? And how would that investment pay adequate social dividends? In examining the political dimension one has to raise such questions as: How would the new communication technology be used to promote greater political participation? How can one avert the very real danger of their becoming potent allies of the existing power structures? When scrutinizing the social dimensions of this issue, it is indeed important to find out such information as the way in which the social consequences in terms of existing structures and patterns of behavior of the introduction of new communication technology, and how best they can be utilized to further constructive social ends. As regards to the cultural dimension, one has to address one's mind to such questions as: Will the new communication technology result in cultural homogenization, cultural domination and the blatant subversion of traditional values, or will they stimulate greater cultural democratization at a higher level? The technical aspect of this issue is as important as any of the others we have had occasion to refer to. Do the Third World countries have the technological skills, know-how and the capacity to make use of these technologies efficiently? How adequate are their training facilities? Finally we need to pay attention to the institutional dimension. I should like to include in this dimension the legal administrative and organizational components. And here the most important question would be: What are the institutional changes that need to be effected so as to maximize the benefits of these technologies?

When examining the question of communication technology and social development there is a widespread tendency to limit the area of discussion to high-cost technologies. But if the discussion is to be relevant to the needs of the developing countries, it is equally important that we pay attention to the low-cost technologies. It is indeed true that with the invention of space satellites, a new age in communication has emerged. The multipoint connections, the vast circuit capacity, the lower cost per circuit, as opposed to the cable, and the reliability and quality in comparison to the high-frequency radio, and its ability to cover large distances without incurring additional costs are all plus factors which any planner in a Third World country would ignore only to the detriment of his own society. But at the same time, it is vitally important that we give adequate attention to the purposeful use of low-cost communication technology.

During the last two or three decades the concept of appropriate technology (it is also referred to as intermediate technology, adaptive technology, soft technology and humane technology) has generated widespread interest among planners in the developing countries. This concept stresses the need to develop and utilize more labour-intensive, low-cost, culture-specific, and context-relevant technology. It seems to me that this concept can be made use of with advantage in the field of communication as well. The development and popularization of low-cost video equipment, cassette recorders, etc., among the vast masses of people in the Third World will certainly contribute toward the achievement of some of the objectives which we stated at the beginning of the paper.

Very often we tend to ignore the potency of these low-cost communication technology in the dissemination of new ideas and opinions. The recent Iranian revolution is a case in point. Whatever the merits and demerits of the revolution may be, one fact became clear--that it established very clearly the power of the cassette recorder as an instrument of dissemination of opinion among the vast body of people. This is of course not to suggest that low-cost communication technology and appropriate communication technology are necessarily synonymous. However, very often these two categories are similar.

It must also be stressed that low-cost technology alone cannot assure that communication technology will be appropriate. The capacity of the people to make us of profitably the more sophisticated technologies needs to be developed. Without the proper technical infrastructure, education, training programmes, and the attendent support managements, these new technologies have the potential to undermine the people's autonomy. The increased access to information and rise in processing capabilities without the infrastructure can do much more than create awareness of alternatives. It could create a destructive dependency on the very system employed to serve the people. It could also raise expectations beyond what can be reasonably met, possibly leading towards instability and a sense of frustration among the people.

The whole question of careful planning and formulating policy is central to the beneficial utilization of communication technology. For example, in the '70s, in many of the Third World countries, there was a dramatic upsurge of interest in satellite communication. Fantastically large sums of money were invested in buying expensive production and transmission equipment. However, there was no parallel interest in making available receiver equipment with the inevitable result that the effort fell far short of expectations. Similarly, the policy makers in the developing countries had not paid adequate attention to the question of training goals need to be formulated in consonance with national goals and aspirations, or else training can become a subtle mechanism of the preservation of the existing power structures and relationships.

When we discuss the role of communication technology, very often we do not pay adequate attention to the fact that there is a vast universe made up of sociocultural, ideological, institutional dimensions closely associated with it. It is only by paying due heed to these dimensions that the policy makers in the Third World will be able to make use of the new communication technology so as to promote the growth of self-reliant, informed, responsible, non-elitist, and participatory democracies in the developing countries. Quite obviously, many of the problems I have outlined in this paper are not susceptible to simplistic solutions. They require the concerted and sustained effort activated by a truly humanistic vision.

LOCAL PROGRAMMING: A CASE STUDY

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Abstract

Local communication systems have been established in rural farming and fishing villages of Japan, and this paper contains a case study of one such system. The hardware system is briefly described and consists of small gauge video equipment, wireless radio, audio cassettes and other readily available equipment. The main body of the paper consists of a description of the local programming and production techniques. These include local newscasts, documentaries, special live transmissions, coverage of a local election, coverage of village meetings, and disaster relief programs. This type of appropriate technology and these approaches to program production may find extensive application in developing countries.

1. INTRODUCTION

The term "appropriate technology" implies a shift of emphasis away from technology toward applications, meaning that the type of programming format becomes a chief determinant of the technology.

Even technologies as sophisticated as television have been miniaturized, simplified and reduced in price to the extent they can now be considered for a broad range of applications in developing countries, but we must ask, are such technologies appropriate?

The key question is, can programming formats (software) be developed for these new telecommunications tools to serve local needs and sustain local interests on a long term basis? If this is to be accomplished, a new kind of person is called for, neither technician nor social scientist, but a combination of both.

In Japan we have seen some of these new people at work in rural villages using very primitive TV equipment, if judged by broadcasting standards, but they have developed effective production techniques and unique local programming tailored to the needs of rural agricultural and fishing communities. These people are by and large self-taught and in some rural areas already have more than ten years experience under their belts.

These are professional local communicators, and we feel their approaches - ways of working - may find extensive application in rural communities of developing countries.

2. BACKGROUND

The Japanese local communicators are based in CATV (Community Antenna TV) stations and are involved in the local origination of programs. Cable networks used with community antennas were established in Japan as early as 1956, two years after broadcast TV was introduced. 1963 saw the first cable network offering locally originated programs which were in addition to the retransmitted broadcast TV services.

Some of the early CATV stations, such as the Shimoda station, are still in operation, but many have dropped out of the picture because of the relay stations which caused a flood of "professional" broadcasted programs.

A 1973 survey revealed the existence of almost 10,000 CATV stations in Japan, most being very small averaging 97 households per station. (1). The number of stations offering some kind of locally originated TV programming climbed from seventeen in 1973 to about forty in 1980.

While the size of the CATV networks varies greatly from station to station, some very large networks have been set up recently. The CATV station in Kofu City, Yamanashi Prefecture has 30,000 subscribers, and the largest cable network to date, 100,000 subscribers, is scheduled to begin operation in Tokyo. The much publicized government sponsored experiments, CCIS and HI-OVIS have been conducted and several lessons learned.

3. HI-CAT - An Introduction

The following pages will describe a case study which focusses on a CATV station located in the village of Inatori on the Izu Peninsula, about four hours from Tokyo by train. Inatori is a rural seaside village with about 4,500 households, and the local economy is based on agriculture, fishing, and tourism. HI-CAT is the call sign of the "Higashi Izu Cable TV" station. Refer to the photographs accompanying the paper. HI-CAT is located in an 8 X 3 meter room on the first floor of a ferroconcrete building, and this single room serves as both office and studio containing all records, production facilities and cablecasting equipment.

HI-CAT was licensed by the Ministry of Posts and Telecommunications in July of 1974 and began operation on November 1 of the same year. The village electronics appliance dealers established HI-CAT to serve as a community antenna for the parts of the village where TV reception was blocked by mountains, and a total of nine stations from both Tokyo and Shizuoka are received and retransmitted to the villagers by HI-CAT. Because there were additional open channels not being used, it was decided to use one of these, Channel 2, to transmit locally originated programs.

HI-CAT is staffed by just three people! One serves as technician maintaining the equipment and cable network, and the other two people are the program production staff. These two produce a minimum of one hour of local programming per day, six days a week, and they have been doing this for five years. In their spare time, the two person production staff also handles the bookkeeping.

Our research in Japan has repeatedly suggested that the production of appropriate programming is not determined by the level of sophistication of the hardware, but rather by the attitudes and ingenuity of the people creating the software. For example, in Inatori neither of the two person production staff had training in professional broadcasting technology. Mr. Noboru Shoji, who served as cameraman, editor and commentator, was high school educated and had two years of experience working in the Shimoda CATV station before coming to Inatori. Ms. Yukiko Suzuki, who served as narrator, interviewer, and editor, did not have any prior experience in TV production.

However, these two people have produced award winning programming under what professional TV broadcasters would consider impossible conditions. (2). To have a Japanese CATV station viable economically, a minimum of 3,000 subscribing households is usually required, but at Inatori there were only 1450. As a result, the founders of the station, that is the local appliance dealers, were hesitant to invest in sophisticated studios and equipment. Actually, this proved to be fortunate. The HI-CAT staff couldn't produce the traditional studio shows; rather, they were forced to do their productions out in the village which became their studio without walls. The driving force behind the HI-CAT "social software" was the rapport the staff had with the local people.

Limited budgets forced innovation and adaptations, often through the use of simple and readily available communication tools such as audio cassette recorders, shortwave radios, as well as industrial and consumer video equipment. At Inatori appropriate technology was simply that which was available and within their means. Let's consider their appropriate technology in greater detail.

4. THE HARDWARE

The last decade has brought an incredible leap forward in what is technologically possible and economically accessible in the field of so called industrial and home video equipment.

The operation of HI-CAT has quite naturally changed according to what equipment has been available and within economical reach of the station during its five year history. The community antenna is situated on top of a small mountain about 3 kilometers from the station. The cable network is a conventional branched coaxial cable system, suspended from poles, and with a number of amplifiers employed as necessary. For this study, the hardware configuration of the cable system is of little interest.

At the outset in 1974, the production equipment consisted of black and white cameras used together with ½" video recorders. At that time the station did not have editing equipment which restricted post production work. This means that the programs had to be cablecast just as they were recorded on location.

After about two years of operation, the first color camera was introduced together with the U-matic cassette video recorders. However, it wasn't until the fall of 1979, after five years of producing daily programs, the first editing equipment was purchased.

Very often the HI-CAT crew uses production equipment in ways rather different from the instruction manuals. For example, the station has never purchased an editing control unit, generally regarded as a necessity in video editing. All editing is done with one U-matic video tape recorder, equipped with editing circuits. Audio and video signals are input into this machine from various portable video tape recorders. The important point is that this way of working saves about a thousand dollars in equipment costs.

In other attempts to save money, it was found that the economical half inch cassette equipment was very adequate for many programs.

It is typical of hardware developments that for the purchase price of a 1976 color camera alone, today, two color cameras and two portable one half inch cassette recorders can be purchased. This new equipment can also satisfy the needs of a local communication system.

In order to save labor, a programmable timer was introduced in 1979. This automatically plays back prerecorded video tapes, meaning that the staff need only be present in the station during one of the daily cablecasts (usually the main evening transmission), the remainder being automatically executed.

Often the narration accompanying a program is recorded live while the program is being sent out over the cable network, and this is done during the main cablecast of the day. This commentary is then played back automatically together with the video portion of the program and other sound tracks during subsequent rebroadcasts.

Although the telop adaptor was developed for conventional broadcast TV, HI-CAT found this device to be very important and found new applications for it as a local communication tool. The telop adaptor can best be described as a kind of conveyor belt bringing up to forty five 9cm X 12cm cards (consisting of hand written or printed messages, drawings, maps or photographs) to the front of a camera. This can be done continuously at a fixed time interval, or the movement of the telop cards can be remotely controlled by the announcer during transmission. An additional adaptor allows telop cards to be superimposed over video pictures.

Even when regular programs are not going out over the cable, the telop adaptor is in almost continuous operation to relay telop cards containing messages out to the villagers. An audio cassette recorder provides background music for the telop cards.

Even when not sitting in front of their TVs, the villagers have a tendency to leave the sets on, tuned to the HI-CAT channel. By occassionaly glancing at the screen, the viewers learn of upcoming programs, messages from the local authorities, weather reports, storm warnings (specially important in a fishing village), public announcements, meeting schedules for local organizations, village events, school information, election results, etc. It is tempting to call this a primitive type of teletext system.

Very innovative applications of readily available equipment such as telephones, copiers, and walkie talkies have given local news coverage a greater impact. We will return to these and the telop machine to describe their functioning during a local election and a natural disaster.

5. SOCIAL SOFTWARE

Picture this situation. One man is alone in a room pacing back and forth watching the wall clock which indicates fifteen seconds before 6:00pm. In the room is a single table with a microphone on top and a black and white television camera positioned in front. All of the equipment required for a cablecast that can be seen by several thousand people is mounted onto a rack next to the table within arm's reach of the announcer's chair.

Fifteen seconds before the evening program, but where are the cameraman and the other crew? All of a sudden, the sliding glass door, overlooking the picturesque harbor with fishing boats rocking in the evening breeze, crashes open, and a teenage girl bursts into the TV studio shouting, "where should I put this soap, it was ordered yesterday." The pacing man, Noboru Shoji, quietly replies, "Just put it on the floor, but hurry up because the evening broadcast starts in about fifteen seconds."

Shoji hurries over to the television camera, adjusts the focus and angle, twists the brightness control on the TV monitor, sits down in the announcer's chair in back of the table, switches on the transmission equipment, and says to his audience of 3,000 - 4,000 people:

"Good evening, this is the 6:00 pm news. Yesterday, the bankruptcy of the Izu Construction Company shocked the people of Inatori. Tonight, we will report on the special village council meeting called to deal with the problems caused by the bankruptcy. As you are all aware, the Izu Construction Company was in charge of building the new village kindergarten, and we are now faced with the problem of finding another company to complete the work. The meeting focussed on this problem, and we will report on the progress."

Mr. Shoji's introduction was followed by about ten minutes of local news and announcements. Then a video tape of the village council meeting was transmitted for about fifty minutes. Mr. Shoji concluded with several more announcements, signed off, and turned on the telop machine. This was an actual program during late November of 1979.

The HI-CAT approach to local news is very low keyed. For example, several years ago a four year old boy disappeared in the nearby mountains while walking with his father. The frantic father returned to Inatori describing the dilemma. HI-CAT was instrumental in organizing search teams, and the villagers closed their shops to join the boyhunt. Here the telop machine played a key role by relaying brief and pertinent information out to the village about the search. Cameraman (Shoji) and interviewer (Suzuki) followed the search parties up to the mountain making mini documentaries about each day's strategy. For three days the people of the village searched, aided by dogs, and the boy was not found. Being late in the year, the nights were dangerously cold in the mountains, and after three nights, the rescue team feared that the boy had died of exposure. On the fourth day, the HI-CAT telop carried out the message that the boy had been found alive in a cave by a dog.

HI-CAT never attempted to interview the frightened boy or the relieved family, avoiding these sensational aspects. Their activities centered on helping to keep the village informed about the progress, thus encouraging the searchers to continue. The attitude of the HI-CAT staff is that certain aspects of daily living are frightening enough without playing them up in the local news.

In addition to the ten minute news programs, a typical evening cablecast will include a documentary about some aspect of village life. These are videotaped on location with the village itself providing the environment for the program. HI-CAT produces a monthly schedule of these documentaries and distributes them amongst the villagers. To give the reader an idea of the documentary themes, we have summarized these schedules in English for the three month period between June and August, 1979.

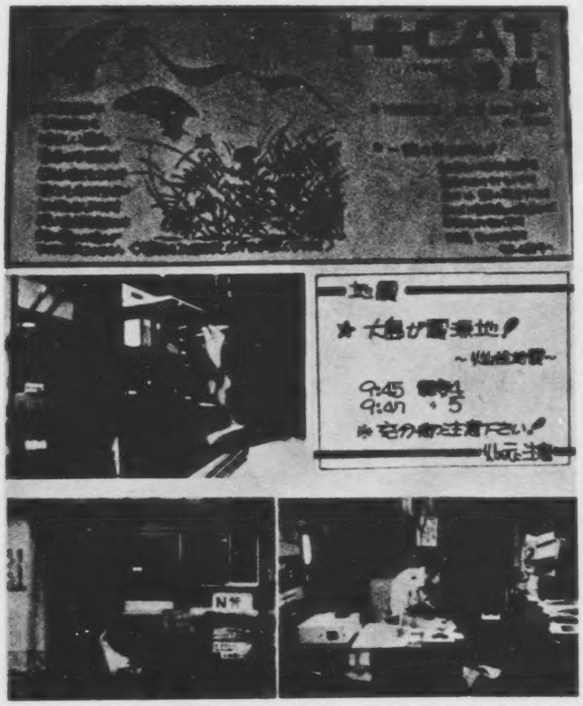
June 1979	Theme
1 - 2:	New records during the Track and Field Meet at the Junior High.
4 - 5:	Old people's and children's sports meet held June 1.
6 - 7:	Inatori toll road problem. Villagers forced to pay because of no alternative routes.
8 - 9:	Workshop on managing forests.
11-12:	Little League game with Shimoda.
13-14:	Lecture on Japanese Language.
15-16:	Repairing Rt.135 damage by earthquake. Need for new bridge.
18-19:	Young people's agriculture. Future of mandarin oranges, an important local crop.
20-21:	Stone statues on mountain, guardian dieties of children. With Toshihiro Kurokawa.
22-23:	Village Topics - local problems
25-26:	Egawa, a local historical figure.
25-26:	Cont'. Lecture by Koichi Ogihara (refer to July 16-17 program)
27-28:	Panel discussion with Kindergarten Teachers, "Children are not Robots of their parents."
29-30:	Junior High Speech Contest

July 1979	Theme
2 - 3:	Human beings of the 21st century, by Heisuke Hironaka
4 - 5:	American-Japanese Wrestling Tournment: Michigan State Junior Champs vs. Inatori High. With Izumi Endo, former Inatori team member.
6 - 7:	Village Council Meeting - featuring the mayor and village coucilors. Listen and see how the meeting is conducted and judge the results.
9 -10:	Dancing at the nursery school.
11-12:	Hydrangea at the sea shore, a local cultural treasure. With Mr. Hatota, culture treasure committee.
13-14:	Inatori twenty years ago. Visiting former villagers who return for local festival.
16-17:	Tarozaemon Egawa - Father of Izu and important personage of the Tokugawa period. First to mount cannons on ships, first to bake bread, established peasant soldier system. Why has history forgotten him? With Koichi Ogihara.
18-19:	Shiranuta Swamps and Ponds - A Virgin area near Inatori. Looking at Ecology.
20-21:	Inatori Karate Gym.
23-24:	Sports Day at Junior High
25-26:	Softball Tennis
27-28:	Suggestions for local development in Inatori.
30-31:	Summary of July's Events.

August 1979	Theme
1 - 2:	Kozushima - An island with a long history located near Inatori, as reported by village youngsters. A beautiful place to visit if you avoid the tourist season.
3 - 4:	Inatori Pool Swimming Meet.
6 - 7:	Following the Inatori fishermen to where they catch the famous golden eyed bream. See how the fishing grounds appear from the boats.
8 - 9:	Patterned after US President Carter's village meetings, Shizuoka Governor meets with the citizens. What will his opinions be? No acting.
10-11:	How to catch a beetle. A method that can't miss.
13-14:	Sixth graders camping at Mt. Hosono.
15-16:	How to double production of your farm. Experiments are underway. Please join.
17-18:	Summer vegetation on Mt. Hosono. Knowledge of plants calms the mind. By Genji Hatota.
20-21:	Business ideas - visiting village stores.

August 1979	Theme
22-23:	What will happen if the road to Shirata is closed?
24-25:	Wine made from Kiwi fruit. Local Sake brewers are interested and farmers will increase production.
27-28:	Kamo County Track Meet. Will Inatori's grueling summer training pay off? Win or lose, do your best.

The actual appearance of the August schedule is shown in the following illustration:



#1 Schedule for August 1979

The people whose names appear in the schedule are village citizens helping to make programs about their own interests, communicating their knowledge to the village. Each of the programs is scheduled to be cablecast for two days. This gives the schedule flexibility, meaning that a rebroadcast of a program can be canceled should an event suddenly occur and require coverage. The local nature of the material is reflected in the themes, and the HI-CAT staff has done a remarkable job in achieving a balanced schedule with varied programming needed to sustain the audiences' interest on a long term basis. While no formal viewer rating system has been established, interviews with the local inhabitants failed to discover anyone not aware of the HI-CAT programs. During the interviews, even people living in areas of the village that could receive conventional broadcasts from Tokyo without tieing into the community antenna expressed interest in receiving the cable service because of the local programs offered by HI-CAT.

In addition to the local news and documentaries, live cablecasts cover meetings and local events. We observed such a live cablecast covering the results of a local election. Conventional communications equipment were very effectively used, and here is how it worked. Mr. Shoji sat in the station at his table with a microphone and black and white TV camera both pointed in his direction. Special telop cards for election results had been prepared beforehand using a copier. Within hands reach were telephones and a wireless radio. Shoji was alone in the station. Another member of the staff drove around the village in a truck equipped with wireless radio, moving from polling place to polling place where the ballots were being counted. As soon as results were known, the roving reporter contacted Shoji by wireless, and Shoji would write the results by hand onto the previously prepared telop cards, slip the cards into the telop machine, and transmit out to the village. Shoji was also in touch with the county election office by phone, and publicized the results of that election using the same method.

If some very significant information came in, Shoji would switch on the camera in front of the desk and make a statement. A single person was manipulating four kinds of communications equipment - TV camera, telop, wireless, and phone. One irate villager phone in wanting to know why Shoji wasn't covering the prefecture and national elections as well. Shoji quietly referred the man to the mass communication channels where the larger elections were being covered.

Live coverage is a very potent tool for the local communicator. For example, let's consider HI-CAT's live coverage of village council meetings. A coaxial cable connects HI-CAT and the village hall, and during council meetings a single cameraman is stationed in the meeting room with a black and white camera. Video signals are relayed back to HI-CAT and out to the homes. Recordings are also made for rebroadcasts.

The manner in which the village meetings are conducted has been effected very positively by the live broadcasts. The village meetwere reported to have been rather unbusinesslike before the live cablecasts began five years ago. The village assembly was extremely hierarchical, meaning that the older members has a tendency to dominate. In extreme cases younger members were not even allowed to present petitions on behalf of their constituency. Older members sent the younger ones out to buy cigarettes during the meeting. However, the live cablecasts changed much of this. In Mr. Shoji's words:

"When a medium such as television is introduced into a rural village, council meetings, local events and programs suggesting problems with the local administration can be cablecast, and this gradually changes the villagers' awareness of local politics. Prior to the HI-CAT cablecasts, villagers simply elected their neighbors and relatives to the village council but had no idea of what these elected officials actually did. Nobody knew what was happening at the village council meetings, and 'village councilor' was just a name..."

"Since HI-CAT began cablecasting five years ago, the local residents have had a chance to see what a village meeting is really like. Now, the villagers are not at all hesitant to question the councilors directly, asking things like, "Why aren't you doing something about this problem or that problem?" Now, the village councilors are judged by their actions. Before, the villagers were simply unaware. The village council members were put up on a pedestal."

"But, now, the villagers encourage the councilors to get on with their work and to follow up on their decisions. This new kind of atmosphere gradually emerged in the village."

According to the HI-CAT staff, the position of the younger council members has improved to the point these councilors now regard it as their right to present petitions, because they represent people in the village, too.

A frequent participant in the village council meetings is Mr. Saito, superintendent of education in Inatori, and he made the following remarks during an interview:

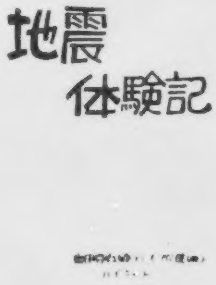
"Since the introduction of television, the village councilors appear live before the villagers, and the villagers can see and hear who is voicing what opinion. In the case of newspapers, reporters gather and interpret the news, but with television the villagers see and hear what is happening live..."

"The villagers, and particularly the older people, watch HI-CAT to find out what is happening in Inatori. They have come to understand how individual councilors think. They hear the mayor fielding questions and recognize when there is a contradiction. People study local affairs as a result of this..."

The authors feel that while the documentary approach is very interesting and worthwhile, the effects of live cablecasts should also be studied because such live work can be a potent tool for political change. This is also a politically dangerous tool when misused.

6. FUNCTIONING IN A CRISIS

On January 14, 1978, an earthquake of magnitude 7.0 struck Inatori killing nine people and devastating the village. After the earthquake, the three members of the HI-CAT staff together with their families moved into the station, leading a communal life for two weeks to aid in the recovery efforts. During this period, they kept a diary describing their daily activities, and this diary contains many insights into the functioning of a local communication system and the production of appropriate social software. The appearance of the diary was as follows:

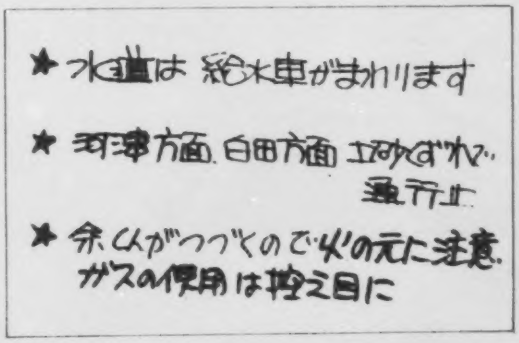


地震
体験記

HI-CAT DIARY

The earthquake struck at 12:24 pm. Equipment was knocked off the shelves at the station, destroying a video tape recorder, but none of the staff were injured. Electrical power service to the village was interrupted for about ten hours. When the power was restored late in the evening, it was found the cable system was intact and capable of transmission. The following card was sent.

TELOP #1



★水道は給水車がまわります

★河津方面、白田方面 土砂くずれで
通行止

★余しんがつづくので火の元に注意.
ガスの使用は控え目に

- CONCERNING WATER - A WATER SUPPLY TRUCK WILL BE MOVING AROUND THE VILLAGE
- ROADS TO KAWAZU AND SHIRATA ARE CLOSED BECAUSE OF LANDSLIDES
- AFTERSHOCKS WILL BE CONTINUING SO BE CAREFUL OF FIRES. USE GAS MODERATELY.

Telop#1 English Translation

There was no need to report about the extent of damage or deaths because the mass communication system takes care of that sort of thing. HI-CAT concentrated on matters of relief such as water, transportation, and fire warnings, for without seeing to these immediate needs, panic would likely occur.

Another significant telop card was sent out on the day following the earthquake, January 15. The English translation of telop #2 is as follows:

"AFTERSHOCKS" ANNOUNCEMENT FROM
THE WEATHER AGENCY

14:38 SIZE 3

CENTER OF DISTURBANCE:
IZU ARCHIPELAGO
ALTHOUGH THE NUMBER OF AFTERSHOCKS IS DECREASING, THEY WILL CONTINUE FOR A LITTLE WHILE. USE CAUTION

Telop #2 English Translation

All but the oldest members of the village had never experienced an earthquake of this magnitude before, making education about aftershocks essential. Poor handling of such matters by the prefectural government was to cause a panic in the village on January 18. We will return to this in a moment.

A live cablecast system was also set up to aid in the recovery. On the afternoon of the day following the earthquake, a blackboard was placed in the village hall, the headquarters for the recovery operations, and all pertinent information regarding water, food, government aid, bathing, mail, transportation, etc. was summarized on this blackboard, A black and white camera was placed in front of the blackboard, and the signal was relayed back to the station and out to the homes, just as for the village council meetings. If the villagers had questions about this information, they were requested to call the village hall or HI-CAT station. If a question received at the station could not be answered, then contact was made with staff members out in the village via wireless radio. These people sought out information to answer the question. The answer was sent back to the station via wireless radio and out to the village over the cable network. This was a very simple information dissemination system with built-in feedback capability. Using this system information could be corrected or modified based on feedback from the villagers. Information was input into the system at the blackboard in the village hall and output through the TV receivers in the homes of the villagers. Reaction to the output was fed back to the input side via the telephone, and the feedback aided in eliminating distortion in the original message.

On January 18 between 3:00 pm and 4:00 pm, rumors of another earthquake spread through Inatori causing a panic. The origin of the rumor can be traced back to the day before, January 17, when the prefectural governor attended a meeting at the National Headquarters for Disaster Prevention. Here some opinions were expressed concerning the danger of aftershocks resulting from the recent earthquake. Disturbed by the information, the governor returned to Shizuoka Prefecture and decided to hold a press conference the following day, January 18, at the prefecture correspondent's club. At the same time, 1:30 pm, a message was broadcast to the village halls in the prefecture through a special wireless system used by the government in the case of disasters. The message began as follows:

"...On January 17 a meeting was convened at the National Headquarters for Disaster Prevention, and the opinion of the group was issued as follows: 1. Aftershocks from the recent earthquake in the seas surrounding Izu Oshima could possibly occur and in the worst case be as large as M6. Because the center of disturbance of the earthquake in this region is shallow, an earthquake of M6 could cause extensive damage..."(3).

The message went on to describe precautions. This message was supposed to be transmitted throughout each village using a loud speaker system.

Both Mr. Saito, Superintendent of Education and Mr. Shoji were at the Inatori Village Hall when this message was received. They studied the content and the wording of the message and realized immediately it would cause panic if transmitted to the village. At the same time, they knew it was impossible to know for certain that an earthquake would not occur, therefore, they felt obligated to transmit an appropriate warning to the village. The wording of the message was changed to:

"More aftershocks are likely to occur, so use caution." The villagers had already experienced four days of aftershocks so this message did not cause panic.

However, in the nearby village of Kawazu, the message received over the emergency wireless was transmitted to the village in its entirety. People with relatives in Inatori called by telephone to tell what they had heard, and this started the panic in Inatori. 1500 people went fleeing into the streets, and many could not be persuaded to return to their homes until late that night. No dangerously intense earthquake occurred.

In response to the panic, the following telop card was transmitted:

> APPRECIATE THE CORRECT INFORMATION ABOUT EARTHQUAKES WHEN YOU HEAR IT.
>
> DO NOT SPREAD RUMORS AND LISTEN FOR THE CORRECT INFORMATION FROM THE VILLAGE HALL
>
> English Translation Telop #3

7. HARDWARE EXPLOSION - SOFTWARE DILEMMA

The 1970s saw a hardware explosion, or technological revolution, depending on your point of view. The 1980s and 90s will bring broadband optical fiber networks, perhaps as prevalent as conventional telephone lines, and direct broadcasting satellites capable of bridging whole continents together. On the production side, equipment will become smaller, simpler, and less expensive. But, what kinds of messages are these hardware systems going to carry?

In Japan the 1970s saw CCIS at Tama Newtown and HI-OVIS at Higashi Ikoma, large scale government sponsored experiments in decentralized local communications technology. In the last year of the HI-OVIS experiments, an attempt was made to develop a social software using a very sophisticated hardware system based on an optical fiber network with two-way capability.

Very interestingly, it was at HI-CAT, not HI-OVIS, that we think the concept of social software has come closest to realization.

The concept of social software implies a high degree of integration of the communication system into the local way of life as well as the acceptance by the residents on a long term basis.

Achieving these depends more on the communicator than on the hardware.

The important point is that these local communicators must be professionals, and as such require not only technical skills but special journalistic skills and an extraordinary awareness of the intricate forces at work in local societies.

It is necessary to determine the kinds of skills that are required, and we feel that a careful analysis of systems already in operation, such as Inatori, could be the first step in this direction.

Moreover, there are many dangers in this type of local communication. A small segment of a society could easily monopolize the medium, using it to libel or destroy other community members.

Serious research needs to be undertaken to determine codes of conduct. Analysis of existing systems could also reveal potentially dangerous situations that have already been encountered.

The key to effectively developing appropriate technology lies in developing the software, and in some rural areas of Japan, pioneers are at work.

NOTES

(1) The Research Institute of Telecommunications and Economics, Some Features of CATV in Japan, Tokyo, 1973.

(2) The Japan CATV Association sponsors an annual competition for CATV programming in Japan. HI-CAT has been awarded the top prize.

(3) Keinosuke Ooki, "Hitori Arukishita Yoshin Joho", Janarizumu Kenkyu, (Journalism Research), Spring Edition, 1978, pg. 71.

Ethnicity in the Native Adoption of Electronic Media in the Sub-Arctic

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Abstract

Specific characteristics of the ethnic dimension are examined in assessments of the impact of television among Canadian Native populations. Longitudinal investigations, started well before initial exposure to television, demonstrate causality in some psychosocial alterations. An emic perspective is employed, and the cultural background is seen as an adaptive system which, with varying degrees of success, adapts television to traditional elements of experience. These latter include several within the supernatural sphere.

INTRODUCTION

In the 1950's and 60's theories about the impact of television frequently employed a rather naive conception of the viewing audience as a passive, malleable, uncomplicated conglomerate which could be moulded into various shapes according to the templates provided by television. Paying little attention to variable viewer characteristics, which might differentially affect television's impact, these theories were often too general, and sometimes contradictory.

More recently, attempts have been made to correct this situation (1). Theorists now more fully appreciate the fact that the impact of television is a variable phenomenon as much dependent upon conditions in the viewing audience as upon the character of television itself. They frequently qualify their statements with reference to specific kinds of impacts which occur with specific kinds of audiences.

Major concern thus far has been with social and psychological variations in television audiences. Until very recently, this focus was adequate. But now that television is spanning the globe, another prime factor must be incorporated. This is culture. For now the viewing audiences not only differ socially and psychologically, they differ culturally as well. Cultural relativity in the study of television is now called for.

The recent introduction of television into small Algonkian groups in remote areas of northern Manitoba, Canada, provides an ideal opportunity to determine whether the impact of television is as much conditioned by cultural factors as it is by social and psychological factors. From Anthropology's very beginnings, the clues to human process have been sought in small cultural groups of non-Western type. It has been felt that the clarity of institutions and practices in such contrasting situations, along with manageable size, would promote scientific control and the elucidation of relationship. The most secure findings in these efforts have been the "mirror images" for Western society, and the processes of change.

To gain insight into ethnic factors that condition the adoption of television among non-Western groups, this approach was again applied. In 1973, when many Native communities in the Arctic and Sub-Arctic of North America had not yet been exposed to television, we set up a longitudinal study of two Native communities -- one which would soon receive television and the other which would not receive television for several years. Additional controls were introduced through the incorporation of another Native community which already had five years of television exposure and a Euro-Canadian community with twenty years of exposure.

Our study reveals that, although television has had certain disruptive impacts, a smooth, conservative incorporation was achieved by a process of "ethnicizing" television. Algonkians are adept at this process and it is the key to understanding their well-documented (2) conservatism in the face of change. It revolves upon a highly resourceful, and highly flexible Algonkian mentality. That mentality is adept at manipulating and stretching the locus of traditional codifications in order to bring new events and technologies within the orbit of traditional meanings. In the case of television, the process creates a hybrid -- an object with Western-derived form and content, but with Algonkian-derived meanings and uses which pave the way for a smooth adoption.

ETHNICITY IN ALGONKIAN ADOPTION OF TELEVISION

In this section we shall discuss five traditional Algonkian codifications to which television has been appended and from which are derived a series of conservative, tradition-based uses. These are: 1) material entities 2) objects with child-rearing functions 3) live, long-distance communication devices 4) objects made by Western Man and 5) storytelling objects. We shall take each in turn and discuss its role in shaping the Algonkian television experience.

Algonkian Materiality and Television

Two factors in the traditional Algonkian approach to material entities influence their television usage. These are a highly developed pragmatism based upon immediacy of needs and an equally well developed pattern of sharing.

The lake-forest adaptation of Algonkian hunters, formed over thousands of years, evolved psychological and philosophic qualities perfectly balanced to permit, within a unique system of interdependent functions, the maintenance of Algonkian culture -- itself the overall means of environmental adjustment. Fundamental to this system was (and to some extent still is) a pragmatism of unparalleled dimensions. The entire material universe existed as a complex of resources readily exploitable by all. A few uncomplicated rules of supernatural governance served to check excesses, but the overall design was predicated upon individual resourcefulness and, in the Man-Nature equation, immediacy. Proper Algonkian enculturation and socialization yielded a person capable of meeting any exigency in a mobile and variable environment. Exploitation, the essence of environmental (and thus material) behaviour was thus characterized by unique events. Continuity and generalization would in this system be dangerous impediments. Fixity, brought on by such a rationale, would serve ultimately to prevent the free execution of artful acts of unique responses to human need and to the constantly changing material universe.

A graphic example of this uniquely Algonkian materialism may be given in the case of an elderly informant's construction of a birch bark drinking cup while on a trip in the bush. The old man needed a cup. He drew his knife and cut a piece of bark from a nearby tree. He then deftly folded it into the shape of a small box. The whole operation took less than one minute. The drinking cup, which was completely watertight and held about a quart, was promptly discarded after lunch. It would have been dysfunctional to keep the cup, to carry it with us in the bush. It would have been cumbersome, awkward, and could very well have interfered with gun handling. Conceivably, a shot might have been missed through carrying it along. The Western mode of materiality is acquisitive, value-oriented, and features maintenance. Now, it becomes easier to explain the difficulty that Algonkians often have with concepts of maintenance -- the derelict tractors and farm machinery, failures in animal husbandry, great reluctance to regularize as in school or work routines. Thousands of years of process have created an internal balance in thought, belief, and action which does not submit easily to external pressures.

Algonkian patterns of television maintenance are understandable within this overall pattern of Algonkian materialism. Initially sets in road-connected communities were bought second-hand, and bounced back to reserves along many miles of rough road. Not infrequently, these sets failed to function when first installed. Eventually, after discarding sets, families came to buy brand new ones as a matter of course. Even these, however, gave difficulties since the written instructions were imperfectly understood. At times, adequately operating sets were abandoned because the controls were incorrectly manipulated or because dealers would not honour a warranty after the jolting road trip. In a four-year period, some families had as many as six sets.

Sharing is also a core element in the adaptive sociology of Algonkians. It ensured survival in a sometimes marginal environment. With respect to initial experiences with television, traditions of sharing brought on a situation in which most every one who was a neighbor or friend or relative felt free to come and go at any hour to see television. This initial viewing pattern caused the early owners of television to lose sleep and privacy, and, as well, any stock of food in the house. Some owners reacted by moving away for a while, or temporarily disconnecting their sets.

Algonkian Child-Rearing and Television

Algonkian child-rearing is characterized by great permissiveness and indulgence. This is felt by authorities to enhance independence and self-reliance in the traditional hunting culture. The pattern persists, despite many changes in the culture.

Children in the Algonkian families of this study are rarely punished, and their actions are not restricted. They receive all the material advantages that their parents (and grandparents) can provide them. How this indulgence becomes translated into problems with electronic hardware is through the unrestrictive manipulation of sets, both through extensive use and adjustment. The cultural rationalizations for this indulgence, which often have supernatural connotations, prevent adults from harshly restraining the children from turning sets on and off and playing with the various controls. While this has undoubtedly had an effect upon the functioning of television sets, its most dramatic influence has been in connection with the use of telephones. Receivers are lifted off their hooks, played with, and left dangling -- sometimes for hours. Those capable of dialing sometimes get long distance numbers, again leaving receivers off after the connection is made. These problems, of course, must be worked out by the people themselves. The values which lie behind the conflicting behaviour are identity-sustaining, and to relinquish them in favour of adopting externally inspired material traits becomes a threatening and stressful contradiction. More often television was exploited for the service of already established needs and values. One instance of this was the use of television as a solution for non-directed means of keeping children home at night. It was played up as an entertainment device for children -- as a "movie" at home. It did, for a time prove effective in this task.

Algonkian Concepts of Live, Long-Distance Communication

There are within traditional Algonkian concepts of communication a series of devices which provide services practically identical to television. The best-known among these is the shaking tent. There was also the mica mirror and dreaming. These traditional communication devices worked with the aid of supernaturals. In the case of the shaking tent, long distance communication was accomplished through the medium of a shaman, who would call the souls of distant people into his tent to speak or be questioned, or could send his own soul travelling to see distant events, or could send a helper-supernatural, like a turtle spirit, to travel and bring back news.

The mica mirror brought information by means of divining. Water was washed over it and reflections provided insights into events occurring great distances away.

Dreaming also served on occasion as a source of news about distant events. It was believed that one could at times dream about what was happening elsewhere or about what would happen in the future. It is to be noted that, among the Cree, the distinction between the future and things happening in geographically distant points is not always clear. In many cases the future for an isolated reserve is indeed that which is happening in distant places like the urban centers.

A most critical point to be noted about these traditional communication devices is that they were capable of uses that television is not capable of, at least not according to Western perspectives on television. Thus, for example, in the case of the shaking tent, it could also be used to steal the souls of people, especially children, and make them die or "act crazy". It could be used to foretell the future. It could provide access to supernatural hero-helper figures. And, unlike television, it could provide personally meaningful individualized communication services as, for example, allowing someone to speak to his brother who might be living hundreds of miles away. It could help someone to discover his own personal prospects for the future.

Personally meaningful insights into the future were also available through mica-divining and through dreaming, and in the latter case there was also the possibility of being put into contact with a guardian spirit, easily the most pervasive religious concept of North American Indians (3).

When television entered Algonkian society and was seen to provide the service of live, long-distance communication, there was a natural tendency to generalize the uses and meanings associated with traditional live, long-distance communication devices onto television. This tendency, which is a well understood part of the core concept of diffusion that has long been a bulwark of anthropology, was solidified by the fact that Algonkians chose to use their Native word for shaking tent ("KOOSAPACHIGAN") as the word which refers to television. As a result, from the very beginning, the Algonkian television experience was focused in two directions -- one negative, the other positive.

On the negative side, it was feared, especially by traditionals, that television was being used to steal people's minds and make people crazy and dependent (especially children). On the positive side, it was felt that television could be used to obtain personally meaningful messages, both about the future and about current events in other places. Algonkian concepts of Western man and of storytelling served to enhance and solidify these two foci of interest.

Algonkian Concepts of Western Man and his Technology

The "White Man" is a "wonderful person" traditionals are heard to exclaim. Their usage of "wonderful" here refers to the more archaic quality of the word as magical, or full of wonder. He is very clever, they say, but also very dangerous. His magic is not in balance with Nature. He uses evil power -- a power based on the exploitation and domination of Nature rather than a balanced oneness with Nature. One Plains Cree traditional put it this way (4):

> ...the Cree has never known and does not know an evil spirit ... but rather well may the Cree believe that the spirit looks with kindliest pity on him, since he has never killed by winds ... never ... by fire. Perhaps it is because he has angered the spirit by putting a stop to the sun-dance lodge, that in such numbers they break up the Canadians' towns ... every day we learn that ... houses have caught fire, every time we go to town .. every summer we hear that ... towns have been destroyed by wind storms ... only the white man was taught by the evil spirit how to acquire wealth ... that is why we are poor.

The well-known Ojibwa artist and traditional, Norval Morrisseau, tells the tale of how Western Man chased thunderbirds in planes, shot them down and then boiled their heads, skimming off the fat and using it to produce electricity (5). This then became the power supply for radio, telephone and television. Ultimately it is the same power supply that runs the shaking tent, for the Algonkian shaman is "licensed" to shake a tent by dream contact with the Thunderbird (6). This is legitimate usage of the Thunderbird power. The Western Man's usage, however, is illegitimate for it is based upon force and exploitation.

A Christian-influenced version of this traditional attitude about Western man is contained in a recent narrative which connects Western Man to Satan:

> We honoured those that brought us. We didn't have any nightmares. Satan is the king of this day. You are God's people. In the beginning, God made the earth and man and the way man should live. But the White Man changed man's laws and also made the earth different.

Traditionals explain that Western Man came to their land and fought with the Algonkians both physically and magically. With his evil powers he defeated them and stole their soul, power, and birth-right. And then he dominated them through spirit possession. He did this first through the spirit of Christ. Then he sent the spirits of alcohol. He continues this now with television.

Early response to the camera provides the precedent for this reaction to television as analogous to traditional soul capturing devices. Densmore (7), reporting on an Algonkian group, states the following: "There seems to be inherent in the mind of the Indian the belief that the essence of the individual or the spirit dwells in its picture or other representation". In connection with the picture she took of a Chippewa child which later died, she comments that though many felt that taking a picture of a child could cause its death, the child's mother assured her that she was not superstitious (8). A more recent illustration of this belief that the camera is a soul-capturing device comes from a man in a Manitoba Saulteaux reserve who requested that his drum not be photographed because he felt that the picture would capture its soul and render it powerless.

This reaction to photography is widespread. Curtis, an early photographer of Native life, was known as "The Shadow Catcher" (9). Carpenter's (10) work in New Guinea is also illustrative, as is the work of Worth and Adair (11) with the Navajo. The long-standing Hopi ban on photographing their ceremonies may also be noted.

Algonkian Concepts of Stories

In traditional Algonkian society, as in most non-literate societies, three factors operate to propel the story into prominence as a teaching, revelational and culture-preserving mechanism. These are the fact that there are no books and no sophisticated means of preserving ideas on surfaces outside of people's minds; the fact that people require great freedom and flexibility to adjust to nature and, as a result, are careful to be non-interfering and non-authoritarian in their relationships; and the fact that there is a decided tendency to explain through the postulation of supernatural hidden forces and, as a result, to more generally view the world as built up from transformations and to contain numerous transformable objects, like witches, which cannot be understood unless the essence behind the surface is revealed.

When it comes to the educational needs of a society, we find that where these three factors are operable the story becomes an ideal educational device. It is short and entertaining and, as a result, easily remembered. And since, without books, memorary aids are important, it can be of service if its characters and plots are shaped in such a way as to be symbols and metaphors for very deep, complex and intricate ideas. And this is readily accomplished in a society well conditioned to seek hidden meanings in objects and events and well-practiced in metaphorical imagery. Furthermore, as a metaphorical, revelational entity, it can teach indirectly and gently. There need be no authoritarian instruction. The legends can be told for their entertainment value and then more lasting lessons can be left for the child to discover by himself when he experiences events that remind him of the legend.

When these traditional conceptions of the story are applied to television which, indeed, is now the most important storyteller in Algonkian society, the traditional is conditioned to seek out important teachings and revelations in television programs.

As an example of this, one traditional gave the following interpretation of the "teaching" contained in the Walton's television show:

> It is just like here. The people live off the land, make things from the forest to trade, hunt, fish and garden, and haul firewood. And there is a road they're trying to put through and the people are trying to fight it, just like here. And there is someone writing a book about it.

As with dream interpretation, the content of the program was made personally relevant and probed for clues as to how to face the future. The man himself had been collecting ethnographic material on his own community and therefore saw the personal relevance of the television show. From his observations of television and his travels to the south he predicts that there will be tall buildings, police, lazy people, and even craziness in the future. "People will be walking around with no place to sleep or eat. There will be no friends to take you in. You will wander around with no job, no skill, and you will die."

To summarize this section, then, the "ethnicizing" of television which takes place upon its introduction into Algonkian culture is the creation of a hybrid form which, in contrast to the television we know of in the West, is less efficiently maintained, more often shared, with access to it largely uncontrolled (even for children), more frequently used for revelations about the future, and more often feared as a destructive, culture-usurping, mind-controlling device.

In the succeeding section we will discuss the impact of these meanings and uses upon the more acculturated Algonkians, and upon Algonkian children.

CONCEPTION OF TELEVISION: ACCULTURATED ELITE AND CHILDREN

The Conception of Television Among the Acculturated.

There is an acculturated pro-West faction, which consists largely of youth, metis and the well-educated, who disagree with many aspects of the traditional view of the world. These people pride themselves on their knowledge of English and of Western ways and they strive to resist stereotypes of them as uneducated, superstitious, ignorant Indians. They consider it an affront if it is suggested that the basic framework of their thought is not the same as that of the Euro-Canadian. They therefore disagree with statements by the traditionals that television is just a stolen idea from the old culture. They view it as something entirely different from the old beliefs about shaking tents, mica mirrors and dreams.

They react to suggestions that there are such similarities as if it is an accusation that they do not understand what television really is. They will be quick to point out that they are quite well aware that television does not work by spirits or by sorcery or by dreams, and that they know very well that the images in it are not real. They know how television shows are made and how camera tricks are accomplished, and how the whole thing is basically Hollywood sham and fiction. By and large, they do not see any insidious plot in television nor any threat to their children. They may even express satisfaction at the idea that television is causing kids to be more open and aggressive. They feel that the traditional person has been too shy and passive and afraid of people and that this has allowed the government to get away with too much. They are not afraid to speak up and say what they feel. They use television largely for entertainment and for something to do when bored and they also like to learn from it about how others live. They do not use the word for shaking tent to refer to television, they just call it "TV". In fact they often use English rather than their Native language in the home.

Conception of Television Among Children

Among children, television is a vast new adventure which reveals the Western Man's world in an intimacy that they have never before seen. They are very curious about this world, envious of it, and anxious to fantasize about it and to copy it. They especially have a proneness to identify with super-heroes and to largely fail in distinguishing between reality and fantasy. Our contention is that this is not simply the result of geographic isolation, the inexperience and natural curiosity of childhood, or a typical child's need for identity. These are factors but their influence is exacerbated by an identity-weak reserve setting, by traditions which exalt identity change, and by concepts of shaking tents, dreams and imitative magic, all of which expand television's role as an agent of identity change and reality.

Longitudinal psychological data collected before and after television entered one Cree community attests to the Algonkian child's adulation of television heroes. The data show that, in comparison with a control group of unexposed Cree children, the exposed group considerably increased their attitudes of aggressive retaliation to an offense (a model of behaviour well-displayed by television heroes), and displayed a greater tendency to identify in fantasy with Caucasian rather than Native hero figures.

SOME EXPLANATIONS OF LIKES AND DISLIKES IN TELEVISION PROGRAMMING

Some General Likes and Dislikes

A clear pattern of preferences in television programming has developed. In general it can be said that favourite programs are action and adventure programs, comedies and cartoons, and nature programs. Most disliked programs were those involving "highbrow talk" (like 90 Minutes Live or Canada After Dark), highbrow music (like Musicamera and Music to See), and those with little action.

In addition, there is a soap opera, Edge of Night, which is all talk and has no comedy or broad action and yet which is one of the most popular programs in the North. There is a great interest in Native language programs which have not yet been attempted but which the people would like to have. There are popular documentaries and specials like hockey games. And then there is the News, which is the major reason people say that they watch television. In a survey conducted among adult Cree and Euro-Canadians, Cree gave News or weather as one of the reasons why they watch television 77% of the time, while Euro-Canadians referred to news or weather only 44% of the time.

There are some special dislikes. Shows with overt sex and nudity like the recently-shown Sear Was Here, which was a documentary of homosexual life in a prison, are singled out for special criticism. There is also a dislike of documentaries that point to the Indian as an alcoholic and "bum". And most especially there is a dislike of explicit documentaries about childbirth, a subject steeped in taboos and supernaturalism. The people are also perturbed with reruns, and commercials, and lack of any choice in programming. They would like to see a number of alternative channels made available.

Some Explanations

One of the major reasons for the preference for broad action adventure shows is because the plots are easy to follow and there is a minimum of talking. One should not underestimate the extent to which language barriers exist in Native attempts to understand and profit from television programs. Almost all Algonkians speak at least some English, but only a very few really understand it the way a native English speaker does. And it's not merely a matter of learning the words. It's learning to use the words correctly. There are numerous examples of uses of English which, though not wrong, are slightly askew. And when slightly askew meanings are built one upon the other, overall meanings can be very much askew.

Further complicating the situation is the fact that our communication is based upon certain unanimously-agreed-upon assumptions about the world which we take for granted but which Native people do not. For example, we assume that time is lineal, that man is causal, and that abstraction and generalization are standard procedure for thought and planning. Algonkian thought on the other hand, except in cases of high acculturation, tends to be non-lineal, fatalistic rather than causal, and particularistic rather than abstract.

Thus Algonkians face a good deal of difficulty when trying to understand what an English speaker is trying to communicate. Hence, when a television show is based on talk and not much else, there is usually a considerable lack of communication and that is why high-brow language shows, like the Canadian Broadcasting Corporation's 90 Minutes Live, and Canada After Dark, were not liked. In fact, among our researched communities, no program in television history was more abhorrent and repugnant than "90 Minutes Live", unless it would be its incredible (and almost identical) replacement, "Canada After Dark", starring Paul Soles. The people of one band persistently approached a field worker asking him to "do something about that Peter Gzowski" (the host). Long distance telephone calls asking (even demanding) intercession in the abolition of the program were received at both the worker's home and office. Visits were made to the worker's office conveying the collective demands of several families. These actions must be viewed against the repressed and passive Algonkian psychology, the principle of non-interference, and the great mass of studies reflecting their inordinate restraint. It is of some value to reflect upon the deeper meanings of this.

The urbane pseudo-sophistication of these "talk shows" is, first of all, transparent to cultures whose close, small-group, family-based experience heightens social sophistication and interpersonal sensitivities. These cultures cut to the full reality of basic human and personal values in a continuously experienced (and used) complex of interrelationships. Urbane artificiality is instantly repugnant, and reflects a completely separate and external set of behavioural values formed within an entirely different cultural and social context. Probably all of the behaviour viewed in the "talk shows" would be seen as "insincere", mostly because it is intended to be "sincere" and not theatrical ("acting") as in the profoundly popular "Edge of Night".

A second reason for the Native rejection of this type of program is the harshly added fact that it is effectively forced upon them. Many had come to enjoy the late movies, and their replacement by an offensively ethnocentric program was a coercive violation of self-determination. The people of our study had no opportunity to express themselves on the matter of programming. This leads us to the important collective desire of Algonkians that they do eventually get some leverage in the selection of programs which may, more dramatically than in the city, alter their social, moral, and psychological lives. While they characteristically have difficulty in imposing restraints upon children, it may well be that some selective authority itself would ameliorate to a degree the most obviously destructive elements. Native programming would insure the strengthening of identity through Native language and news.

SUMMARY

The examination of television consumption in Northern Algonkian bands has brought out themes of acculturation common to all mankind. A number of critical elements are seen to revolve around the maintenance of ethnicity and identity. Algonkian psychology is characterized by non-aggression, and is, in fact, almost universally cited by social psychologists as a model for this. Television has abruptly provided a massive battery of observable aggression. There are indications that this may be altering behaviour. Violence to the point of community dysfunction and anomie in one band has followed the introduction and growing experience with television, apparently independently of urban-connection through road extension and continuous alcohol supply.

Television has brought conflict between traditional values pertaining to child-rearing and observed effects of television upon the young. Since traditional values in this feature permissiveness and indulgence as agents in the development of normal adults, the violation of these values threatens the very core of life. The dilemma facing the people in this becomes doubly anxious because it is felt to be forced.

Any violation of the concept of self-determination in any cross-sultural setting promotes identity defense. Great variety attends these defences, but violent behaviour is a common theme. It may be that the violence so commonly seen today on some reserves may, in part, be caused by frustration at the inability to control significant influences upon life. It television has indeed come to have such a basic impact, the ethnically offensive elements (like "90 Minutes Live", sexually oriented commercials, and even perhaps golf) come to symbolize a lack of self-determination. This "captive audience" condition probably aggravated the responses to expecially undesirable programs.

The overall portent of our study at this time is a need to provide Native populations consuming an externally inspired set of incluences, a means of controlling that reception. This should service to reduce the frustrations deriving from unilateral decisions about content. Native programming offers some amelioration of this stress, but this will not change the majority of television content. Even if program content were altered radically, a highly significant array of especially offensive material would remain in the ever more frequent commercials. Disgust would be an inadequate word to describe reaction to feminine napkin commercials in a society which traditionally has exercised numerous taboos in connection with menstruation, even to include isolation. The competitive themes, and the acquisitiveness underlying much of the commercial broadcasting lead to confusion and diminished self-worth. Much of that pictured in commercials forms the epitome of extravagance to the average Native family. But to those sucked into the actual process of television-induced consumption, it can form the difference between a marginal existence and true poverty. Even now there are occasional indications that traditional themes on child care have prompted response to child-directed commercials. More and more often, the expensive 10-speed bicycle is seen in the hands of children of very poor families, in an area where there are very few places to ride them. It remains to be seen if "object-association" will tend to replace social orientation through toy commercials as has been asserted for urban groups by M. Goldberg of McGill University (12).

It remains for us now to embark on a far more exhaustive investigation to determine if our findings for Algonkians may be applied to other non-Western peoples. There is reason to believe they may, for there is, in every non-Western society, parallel traditions of shaman soul flight, story-telling, Western man and image-making. These may create certain standard non-Western meanings and impacts of television which may be anticipated and perhaps, be more sensitively handled.

NOTES

1. Bandura 1978:12.
2. Hallowell 1967:119, Barnouw 1950:12,76, Dunning 1959:5, Landes 1961.
3. Benedict 1923.
4. Bloomfield 1934:5.
5. Morrisseau 1965:6.
6. Carter 1977, Hoffman 1891:157, Jenness 1935: 66.
7. Densmore 1929:70.
8. Ibid 1929:151
9. Knickerbocker 1977.
10. Carpenter 1972.
11. Worth and Adair 1970.
12. Goldbert 1979.

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Videotex: Beyond the Technology Questions

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Following a review of current issues in the development of videotex, this paper examines the relationship between videotex and the more traditional news media. How videotex alters the nature of news and the dominant paradigms of society are discussed. Finally, the importance of access and electronic literacy are stressed.

The alleged arrival of the Age of Information---the Post-Industrial Society (1), the Third Wave (12), the Wired Society (9), call it what you will---has been hailed with Hooverian promises of a microprocessor in every pot. We'll save energy by working at home, gasoline by shopping via computer. The television set, no longer content with its role as entertainment device, becomes not only a "home information center," but detects burglars, cooks the pork chops, and feeds the dog as well.

Some, of course, take a dimmer view, claiming that these scenarios focus too narrowly on the content of the new media. Preferring to deal with the issues surrounding the process of communications, this group paints a grim picture, seeing our privacy being invaded, our individuality transformed into a series of binary blips, our interactions with other humans cut short as we gather about dim VDT's in our electronic caves.

In all likelihood, the future lies somewhere between the gloom and the glory. Both process and content are important, but the real issues remain veiled unless we step back from the media environment we've created. What factors inherent in the technology shape what the medium can become? How does the structure of the institutions surrounding the new forms of communication reinforce old patterns and legitimate new ones?

The marriage between computers and broadcasting--and its firstborn child, videotex--lends a new urgency to these questions. Only a decade ago, the concept of a computer-based information utility available for use by private citizens belonged in the realm of science fiction. Today, videotex threatens to mold the way in which individuals receive information about the world. (I refer especially to the "industrialized" nations, but the medium may soon expand into the LDC's.)

What is videotex, exactly? That question plagues everyone who comes into contact with the medium, since it can't be defined merely on the basis of physical form. Essentially, a videotex system allows an individual to access the information in a computer databank and have it displayed on an ordinary television screen. Relatively inexpensive equipment attached to the set--a decoder that translates the computer's signal into readable form and a calculator-like keypad used for requesting the information--complete the set-up.

A videotex signal may be transmitted in either of two modes. The broadcast version, commonly called teletext, simply piggybacks the computer signal on the regularly transmitted television signal without disrupting normal programming. Wired systems, called viewdata or videotex, send the computer signal through telephone wires or coaxial cable.

The specific means of transportation naturally affects the structure of the database: teletext may be thought of as a system designed to transmit large amounts of perishable information to an infinitely large audience; viewdata, as one that sends an infinite amount of (relatively) nonperishable information to a limited audience. (5) The central point, however, is not the form of the system but its function. Whether through viewdata or teletext, the user does the same thing: connects to a computer, peruses an index, and selects information to be viewed. Videotex is a very nonthreatening introduction to computing.

I feel compelled to insert a caveat at this point: videotex systems are only now emerging as viable commercial operations. Although corporations and governments worldwide are conducting experiments, most systems are at the prototype stage. With the field in such a preliminary phase, we must seek not the right answers but the appropriate questions.

The Technology Questions

Videotex entered the world in the same manner as most other communications developments throughout history--chaotically, with an emphasis on hardware and technical development. Videotex inspires inquiry into those areas, because it moves computing into the popular arena. It seduces the unsuspecting user by making the acquisition of information fun: simply pressing a button makes news, graphics, and games appear on the screen. Hence, engineers face an interesting problem: how to design a sophisticated computer system to be used by people who panic at the sight of a square root function, while keeping the cost of the equipment down.

The issues today have moved from specific system designs to broader questions involving standardization of displays, graphics capability, and decoder compatibility. These questions, raised on both a national and an international level, will of necessity be answered soon.

The Marketing Questions

Videotex is a technology in search of a function. Corporations sponsoring systems must create an awareness of the availability of videotex while instilling a demand for the sorts of information provided by the medium. At the same time, their market researchers must uncover the information needs and wants of their target audience.

The focus thus far has been on consumer preference in terminal design and database content, simply extensions of the technical questions on a consumer level. Some researchers, however, are beginning to ask more consumer-oriented questions concerning the actual needs of individuals and the role that videotex will play in the home. (2)

The Policy Questions

There is no commercial videotex service in the States at this time, and therefore no videotex policy. Certain topics appear mandatory for inclusion on the agenda, however, the foremost being the definition of the medium: is it print? broadcasting? computing?

That definition will help resolve other issues that are likely to arise, such as privacy, copyright, cross-ownership, and editorial control. (3) It will not solve the need for a national information policy nor will it close the growing gap between the "information rich" and the "information poor," both domestically and abroad. (10)

The Sociocultural Questions

The above questions have a certain immediacy to them; they must be answered in order for the medium to come into existence at all. But another type of question, easily pushed aside "for future consideration," shares at least the same level of importance. This set of questions explores the potential impact videotex has on us, individually and collectively.

The central issue here is the nature of the medium itself. Videotex certainly packages information in an attractive manner, but it is not simply a passive wrapping within which the information flows freely. The technology itself places constraints on its content.

One constraint is physical: the information must fit in the space allowed by the television screen. It can't slither off the margins, and the user must be able to read it clearly. Another constraint is economic: most systems charge the user on the basis of how many screenfuls of information (s)he accesses. A news story can't be continued on the next screen, since there's no guarantee that the user will turn the "page."

The creator of the information, author cum electronic publisher, works within these constraints, arranging the information within a tightly structured framework of a specified number of characters per line and lines per page---electronic haiku. The contents of a preexisting medium cannot simply be dumped into a videotex system; videotex shapes the information to fit its own architecture.

Is Walter Cronkite Obsolete?

Videotex, as a new information dissemination technology, necessarily alters the ratios of audience and advertisers among the traditional media. Publishers and broadcasters, realizing that point, rushed to establish themselves as major actors in the development of the medium. The impact of videotex surpasses simple economic rearrangements, however; it alters the nature of news itself.

Videotex revives the paradigm of the printed news story even as the instantaneity provided by the computer antiquates television and radio as the speediest carriers of information. The notion of the linear and sequential emphasized by print enters a renaissance fostered by videotex. (8)

The difference between print and videotex hinges on the entrance of the computer into the information dissemination process. In a traditional newspaper, stories appear in weird juxtaposition on a single page: Billy Carter's escapades and war in Iraq rest together atop a picture of children frolicking in the park. Print's linear content appears in a simultaneous format.

Videotex news, while linear in content, presents an interesting conflict in the definition of format. Since the user can't simply glance up to find a story of interest as (s)he would while reading a newspaper, (s)he must let the computer be her eyes. The only way to tell the computer what to display is to press the appropriate buttons on the keypad. Systems designers, in an effort to make videotex easy to use for the consumer uninitiated in computerese, arrange information in a "tree structure." Unless the user happens to know the five- or six-digit number corresponding to the "page" on which the information is stored, (s)he must consult a general index which sends her to more and more specialized indexes until the target information is reached.

This can become a lengthy process: one user of Britain's Prestel, the service operated by the British Post Office that sparked world interest in the medium, recalls being routed through 26 indexes before the desired information appeared on the screen. (11) Once the user follows the parade of indexes to find one item, (s)he must backtrack at least one index (and usually more) to get to the next piece of information, continuing until (s)he turns the set off. The process is recognizable as linear but the lines cross and recross one another.

A closer look at those electronic lines reveals that they serve as safety nets for information. The computer's capacity for storing large amounts of information conflicts with the human need to digest it in manageable chunks: meaningful connections between sections of the database protect the user from being overwhelmed. Checking tomorrow's weather forecast shouldn't entail wading through the bus schedules to Albuquerque, even if they immediately precede the weather in the databank files.

The information exists simultaneously inside the computer, however, and the user can instantly access any piece of it by pressing the right buttons. But once the user does that, (s)he commits herself to the tree structure and a linear course of action. As you follow the tree, your choices become narrower and narrower--you lose many of your options.

This superimposition of linear sequencing on a mass of simultaneously and instantly available information restructures the way in which we think. Conscious thought operates in two primary modes: the prefrontal region of the left hemisphere regulates our use of language and logic; the right hemisphere controls spatial and holistic perception. (6) Just as the invention of the alphabet created an environment which encouraged the ascendancy of the left hemisphere and television's technology reestablished the importance of the right hemisphere (7), videotex readjusts our conceptual processes. Its hardware--simultaneous, instant, and holistic--battles with the software--linear and logical--for our mode of perception.

What is the significance of this linear simultaneity? It means that news is not ordered conceptually for the user. News becomes fragmented. When you read a newspaper or watch the evening news, you often discover some event you hadn't heard about, quite by mistake. Not so with videotex: you decide to view specific information on the basis of the choices offered to you by the index. The system might call some particularly extraordinary happening to your attention when you turn your videotex set on, but you're not likely to run across it by mistake--the price structure and indexing tree discourage that.

The importance of this exceeds the notion that you might not hear about a border conflict in Afghanistan for three days. The point is, much of our knowledge of our environment relies on our pulling together of hitherto unrelated facts and ideas, and the fragmented and disconnected method of information retrieval on videotex stymies such synthesis by making the facts themselves harder to find.

Furthermore, the electronic nature of the medium, allows the constant updating of news. The potential to have the latest developments stored online increases the probability that less-than-current versions of a story will be deleted from the databank, destroying the permanent record of events. Erasing the permanent record erases the history of a people, and those who control the past control the present, and by extension, the future.

The need for a diversity of channels, decentralized and lateral connections that provide access to information, is clear. (9) The new information technologies, far from becoming demassified, reassemble themselves into a seamless web that envelops our consciousness.

The MacDonald's of Telecommunications

Magazines began as general interest publications (Life and Look, for example) and only later moved into specialized areas. Network television is now being challenged by cable networks that cover news, sports, religion, and the like in a depth that the networks can't begin to touch. Videotex, on the other hand, starts as a specialized medium.

The content of a videotex database appeals to many diverse interests but in economic terms, the medium assumes a certain audience. It is geared toward people who can afford the hardware (decoders run from $250 for the ABC/NBC/PBS-sponsored closed captioning system to over $1000 for Canada's Telidon) and will pay for access to videotex databases. These people are likely to be able to afford to do the things listed in the database--visiting local restaurants and buying stock, for example.

People who can afford such things can also afford to have other sorts of information (magazines, cable television) entering their home; they're aware of sources of information and how to use them. (4) Videotex widens the gap between the information rich and the information poor, perhaps even turning the former into an information elite. (10)

But videotex is only one option among many, runs the counterargument. It won't replace the morning newspaper--after all, you can't fold a terminal and carry it on the train with you--and its emergence merely indicates the prevalence of choice where little existed before. (12) This view not only neglects the differential in access among social classes; it also fails to consider the limited choice of information provided by the machine. Your choice is predetermined by the menu, as the engineers style the index: you can choose, but only within the framework they offer you. The menu asks if you'd prefer pickles or onions on your hamburger, never questioning the idea of having a hamburger in the first place.

Access must, then, exist on two levels, access to the medium itself (the hardware) and user input into the database (the software). The first is simple: whether through coin-operated terminals in public places, library participation in making terminals available for use free of charge, or government subsidies via information stamps (much like food stamps), videotex equipment can be made available for the various publics to use.

User input may be more difficult to accomplish. As it stands today, only those with strong financial backing may enter information into the databanks for public consumption. Although many organizations publishing on videotex are new to the communications field (J.C. Penney, British Airways), most of the names are familiar--RCA, CBS, AT&T, Knight-Ridder. Provisions should be made for a segment of the database to be open to consumers to enter whatever information they feel to be pertinent, something equivalent to a public access channel or letters-to-the-editor column.

The problem is not technical--The Source, Telecomputing Corporation of America's computer database network, includes a section where users can contribute their own information, and videotex systems could easily be adapted to accomodate such a space. The keypad would have to become a full keyboard, but that's the direction the evolution of the technology is moving in, anyway. Second and third generations of most videotex systems will probably include full keyboards as standard equipment.

The problem is political. The gatekeepers of videotex bemoan the awful possibilities engendered by such an innovation, fearing obscenity, slander, or worse as the citizens get their hands on the computer's memory. Certainly, some sort of editorial control is appropriate but the space for consumer input should be cleared now, while the medium is in its infancy.

This assumes, of course, that people will take advantage of the opportunity to help shape the new medium, and that they will be capable of doing so. Videotex requires print literacy as a prerequisite to any more sophisticated use--people must be able to read the words that appear on the screen--but it also demands computer literacy.

Literacy implies not only reading but writing as well. The reason the printed word is less mysterious to us than the television broadcast is because we know how to write but don't have the equivalent skill for television. Computers ease the shift into videotex literacy by building on a skill we already possess--print literacy.

That's not to say that making the space available will automatically ensure that the medium will be used as a democratic tool, but educating people in its use will aid us in dealing with technology on our own terms. There's no reason that invention has to be the mother of necessity; we can design and use the media for human needs.

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THE PROPOSED NEW INTRAEXCHANGE - INTEREXCHANGE STRUCTURE FOR U. S. DOMESTIC TELECOMMUNICATIONS

A PRELIMINARY FEASIBILITY ANALYSIS

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Abstract

Various legislative proposals are being considered in the U. S. Congress to restructure the existing U. S. domestic interstate - intrastate jurisdictional telephone operations into interexchange and intraexchange operations. Additionally, such restructuring will be of importance in the development and evaluation of specific structural alternatives associated with the divestiture being requested by the U. S. Department of Justice in its antitrust action concerning the American Telephone and Telegraph Company.

This latter activity notwithstanding, a preliminary analysis of the toll-switching hierarchy in the U. S. indicates that the proposed restructuring of jurisdictional operations is feasible by considering the appropriate level at which such demarcation can occur. Moreover, it would appear that the specialized common carriers could interconnect at this same level to provide interexchange services without creating any technical or economic problems that cannot be resolved within the existing framework and procedures used for inter-carrier coordination and compensation. In this way, competitive "parallel" service networks could be developed compatibly with the existing network hierarchy.

SUMMARY AND CONCLUSION

A review of the current legislative proposals to restructure the existing interstate - intrastate jurisdictional telephone operations into interexchange and intraexchange operations indicates that this proposal appears feasible. A brief review of the existing toll-switching system hierarchy in the U. S. indicates that the proposed demarcation for such restructuring can be focused at the class 4 toll center offices within the existing system. Moreover, it would appear that the specialized common carriers could interconnect at this level to provide interexchange services without creating any technical or economic problems that cannot be resolved within the existing framework and procedures used for inter-carrier coordination and compensation. In this way, competitive "parallel" service networks could be developed compatibly with the existing network hierarchy.

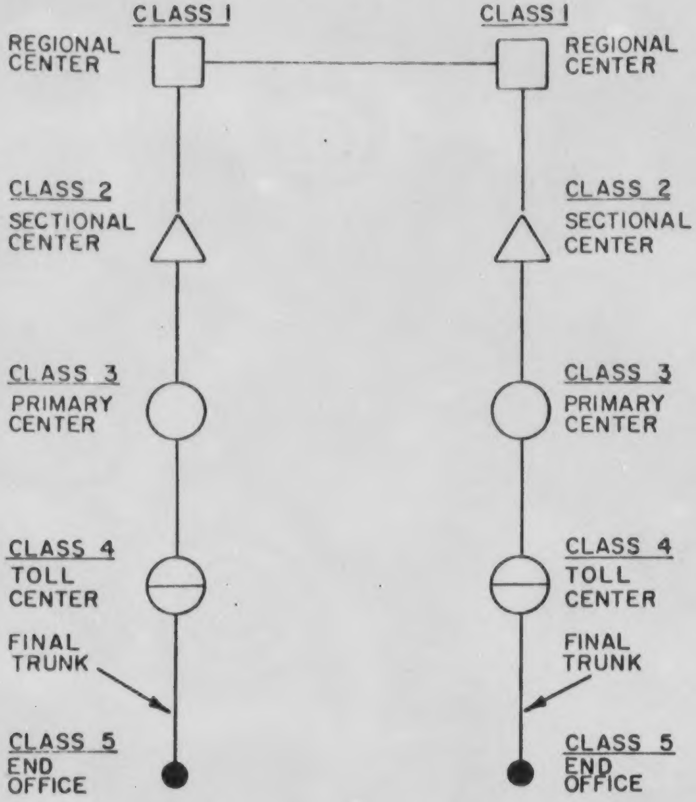
REVIEW

Specialized common carriers (SCCs) in the communication field depend upon local telephone service for distribution to and from their terminals or switches to subscribers for their services. In most cases, they are limited in completing a connection and have other distributional limitations due to the necessity of interconnection to only a local telephone exchange in a given area. Under the existing system organizational framework, network access is made through what is known as a class 5 office or local exchange. The procedure could be simplified, network access expanded, and end-to-end cost perhaps lowered if arrangements could be made to enter the national toll network at a level higher than a local exchange. These deficiencies can be overcome by adopting the presently proposed legislation which will redefine the current jurisdictional state-interstate toll structure into an intraexchange and interexchange structure.

The inherent compatibility of the existing and proposed structures is best explained by examining the hierarchy of the existing national toll network.

In the toll system plan for North America, including Canada, Mexico, the Maritime Provinces, and the United States, these areas have been divided into a number of Regions. Each Region has been subdivided into Sections. In turn, the Sections are further subdivided into Primary Areas; all

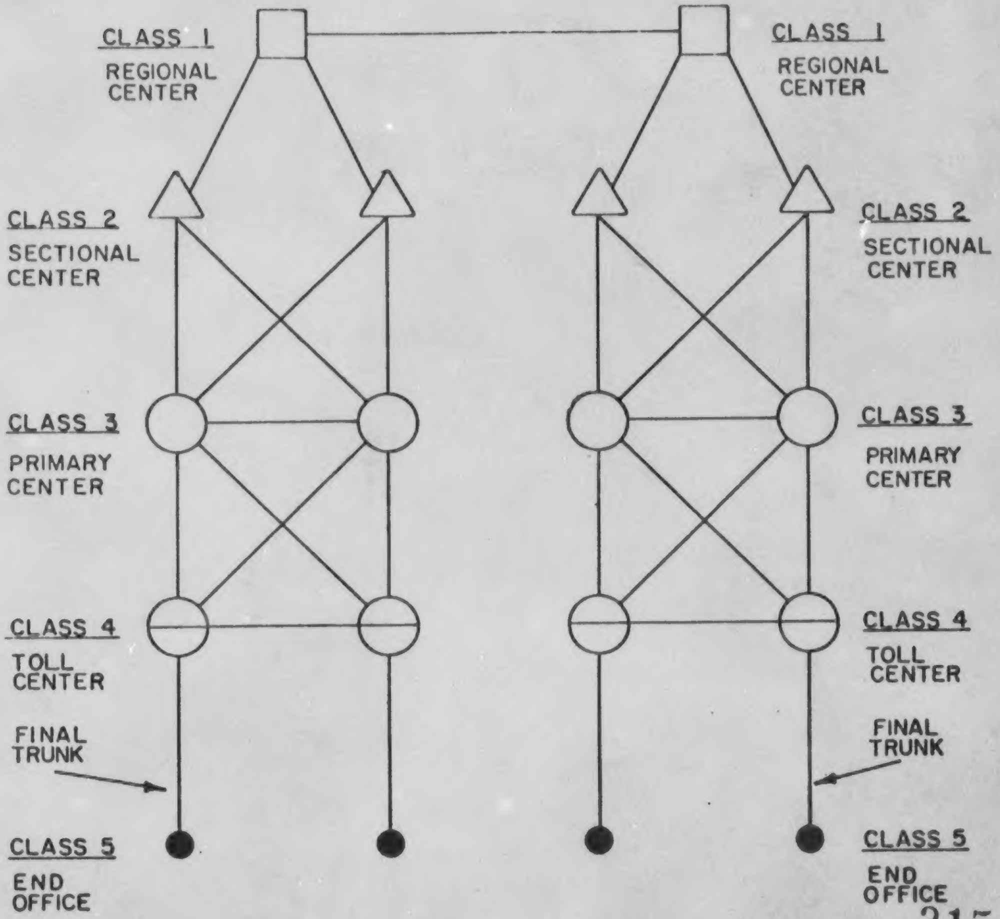
FIG. 1
BASIC TOLL NETWORK


CLASS 1
REGIONAL CENTER
CLASS 1
REGIONAL CENTER
CLASS 2
SECTIONAL CENTER
CLASS 2
SECTIONAL CENTER
CLASS 3
PRIMARY CENTER
CLASS 3
PRIMARY CENTER
CLASS 4
TOLL CENTER
CLASS 4
TOLL CENTER
FINAL TRUNK
FINAL TRUNK
CLASS 5
END OFFICE
CLASS 5
END OFFICE

Source: Notes on Distance Dialing, 1975, American Telephone & Telegraph Co.

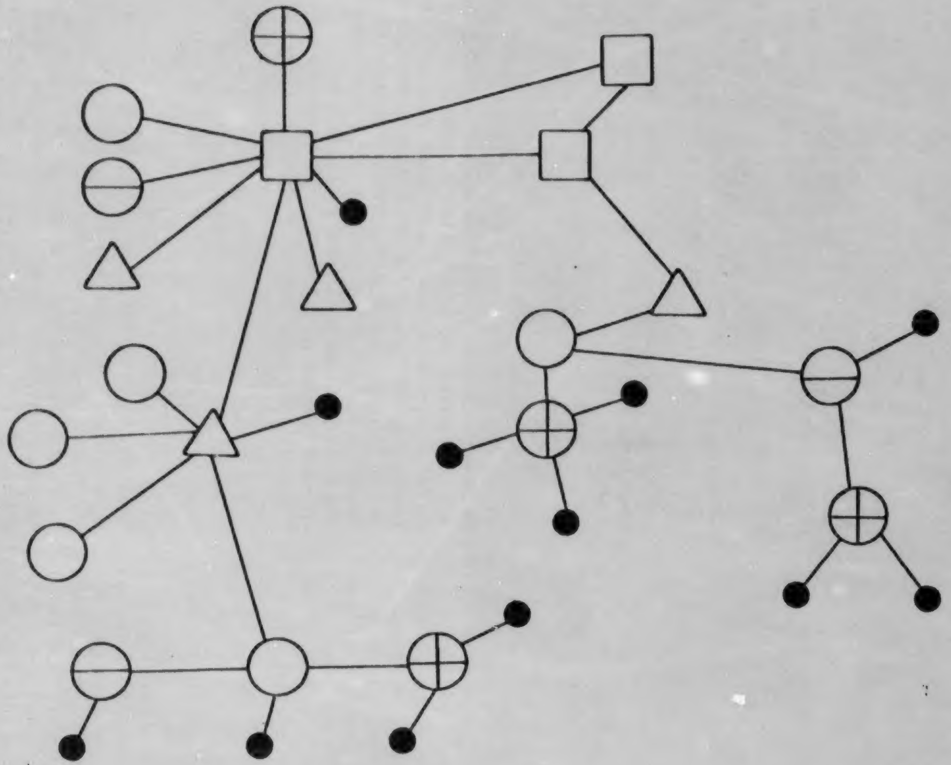
C5-2

FIG. 2
INTERCONNECTING AND ALTERNATE ROUTING PATTERN


CLASS 1
REGIONAL CENTER
CLASS 1
REGIONAL CENTER
CLASS 2
SECTIONAL CENTER
CLASS 2
SECTIONAL CENTER
CLASS 3
PRIMARY CENTER
CLASS 3
PRIMARY CENTER
CLASS 4
TOLL CENTER
CLASS 4
TOLL CENTER
FINAL TRUNK
FINAL TRUNK
CLASS 5
END OFFICE
CLASS 5
END OFFICE

Source: Notes on Distance Dialing, 1975, American Telephone & Telegraph Co.

FIG. 3
TYPICAL SWITCHING PLAN



NOTE: TOLL POINT IS DEFINED AS A LOCATION WHERE OPERATOR ASSISTANCE IS PROVIDED ON OUTWARD CALLS.

Source: Notes on Distance Dialing, 1975, American Telephone & Telegraph Co.

SYMBOL	CLASS	NAME
□	1	REGIONAL CENTER
△	2	SECTIONAL CENTER
○	3	PRIMARY CENTER
⊖	4C	TOLL CENTER
⊕	4P	TOLL POINT
●	5	END OFFICE
—	FINAL	TRUNK GROUP

very much like the geographic divisions and subdivisions of the United States.

There are toll switching centers for each level of the subdivisions as shown in Fig. 1, the Basic Toll Network. Within the Primary Area there is further subdivision in order to bring the system down to a local area and connections to the individual subscriber. Each level or stage of progress in the hierarchy has been assigned a class number with the largest number being given to the local exchange.

Traffic in the long distance services is routed via the various switching centers to the Regional center prior to being connected to another Region. Traffic within a Region goes through the next higher center to travel to the adjacent area. The network pattern is illustrated in Fig. 2, Interconnecting Pattern; thus, the term "the Toll System hierarchy."

As a means of further illustrating the system concept, let's follow a call from a telephone station in Washington, D.C., to the west coast. The call is routed from the immediate neighborhood to the 13th Street office, then to "Garden City," Virginia, across the river. From that point, there are direct trunks to San Francisco (a Region to Region connection) at which point the distribution process takes place. What has happened in this arrangement is that the initiated traffic is concentrated in stages to make use of a common facility for transmitting over long distances. Then there is a decentralization or distribution to reach a local station in the called area.

In rural areas the hierarchical relationships, including independent telephone companies, are essentially the same. Consider, for example, New London, Minnesota, which has an independent telco providing service to about 2000 stations. The class 5 independent office is tied into a Bell System class 4 toll center at Willmar and then the Sectional center at Minneapolis and ultimately to the "Norway" Regional center in Illinois. Thus, a long distance call originating in rural New London, terminating in Sacramento, California, would follow this path to the Regional center in Sacramento for completion at that end.

In some cases, depending upon traffic demands, a number of Regional offices may be interconnected directly to each other. Thus, there are direct trunks from east coast to west coast, or Washington to Chicago, or Atlanta to Chicago. Where the amount of direct traffic does not support a direct trunk system, the connection may be relayed through one or more Regional offices. Under conditions of unusually high traffic demands, the calls may be routed over alternate routes between Regional offices and, as well, Sectional offices as shown in Figs. 2 and 3.

One method of interconnecting and alternate routing is shown in Fig. 3. Also in this figure, it is shown that in the interest of economies (e.g., minimize the number of switches and switching points) all offices in the system organization are designed to perform the functions of several levels. That is, a class 2 office can handle the class 3 and class 4 traffic as well. Certain technical criteria have been established with the objective of keeping the traffic as low as possible in the hierarchy on an equitable (i.e., traffic density) basis, while maintaining capacity within the hierarchy for both alternate routing and normal hierarchical routing. Thus, the entire scheme has been designed to be flexible in the many arrangements needed. A graphic representation of the current toll hierarchy within the U. S. is shown in Fig. 4.

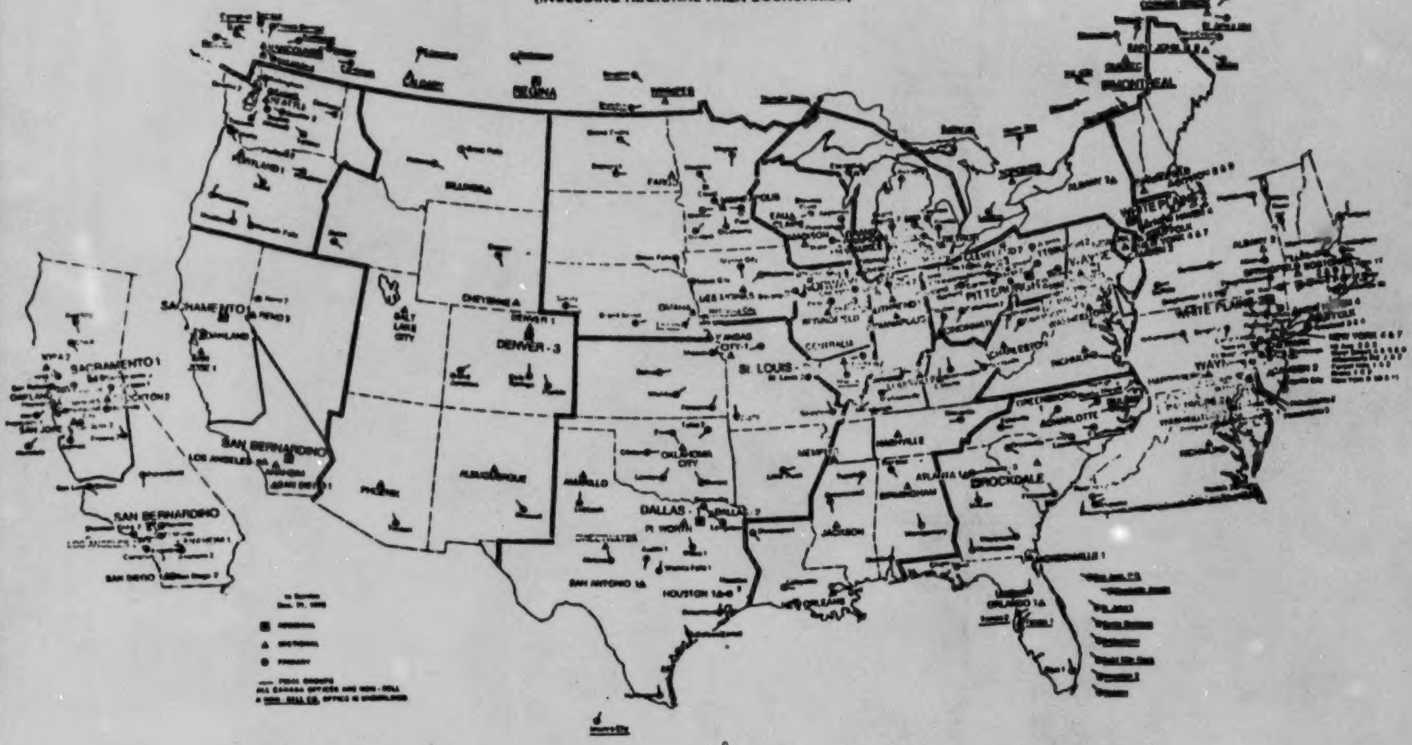
The intricacies by which switching takes place in every one of these centers are technical details that have been omitted for purposes of this discussion. It is sufficient to state that each switching point is tailored to meet the immediate requirements of its location, quantity of traffic to be handled and call routing. The circuit quantities and facility arrangements are normally determined by traffic studies for the circuit quantities and economic selection for the facilities (e.g., present worth of annual charges). Ultimately these data are negotiated and mutually agreed upon by the different companies involved.

The problem addressed in this document is the potential for establishing an intraexchange - interchange delineation of this network hierarchy and the potential for access to this "new" structure by the specialized carriers without disturbing the techno-economic relationships established within the current structure.

Initially, it is interesting to note that AT&T appears to view its current local office interconnections for its own local and toll offices in much the same way it views interconnection for the specialized carriers. For example, Figs. 5 and 6 (taken from materials submitted by AT&T during the ENFIA negotiations) show the specialized carrier facilities (MCI - EXECUNET and Southern Pacific - SPRINT) as merely being interposed between local/central offices, acting in lieu of the class 4 toll office and toll trunk connec-

FIGURE 4

DISTANCE DIALING NETWORK - END OF 1975
(INCLUDING REGIONAL AREA BOUNDARIES)

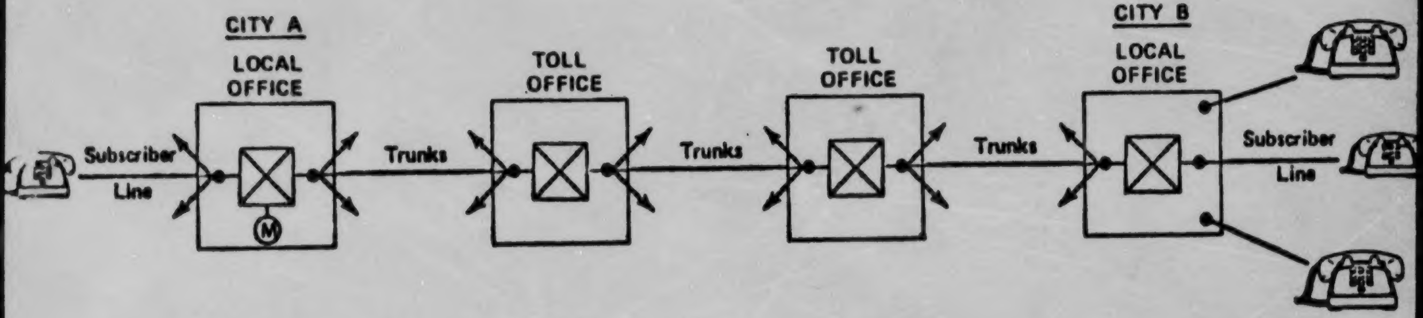


REGINA
SACRAMENTO 1
SACRAMENTO 1
SAN BERNARDINO
SAN BERNARDINO
LOS ANGELES
SALT LAKE CITY
DENVER - 3
ALBUQUERQUE
PHOENIX
OKLAHOMA CITY
DALLAS
FT. WORTH
SAN ANTONIO 1A
HOUSTON
NEW ORLEANS
JACKSON
ST LOUIS
KANSAS CITY
MEMPHIS
NASHVILLE
ATLANTA
ROCKDALE
CHARLOTTE
JACKSONVILLE
ORLANDO 1A
PITTSBURGH
CHARLESTON
RICHMOND
WAYNE
WHITE PLAINS
NEW YORK
BOSTON
ALBANY
MONTREAL

Source: AT&T Response JB-66
FCC Docket 20981

FIGURE 5

MTS
(MESSAGE TELECOMMUNICATIONS SERVICE)



Source: AT&T Letter to FCC
September 28, 1978

MTS - TYPICAL CALL

To initiate an interstate MTS call, the originating subscriber goes off-hook and receives dial tone from the serving local office. The subscriber then dials 10 digits, the 3-digit NPA* code and the 7-digit exchange telephone number of the called station.

Upon receipt of those digits, the local central office recognizes this as a toll call, attaches Automatic Message Accounting (AMA) equipment, connects the subscriber line to a toll connecting trunk which is terminated in the toll switching machine located in the toll switching office, and forwards the 10 digits to that toll switching office.

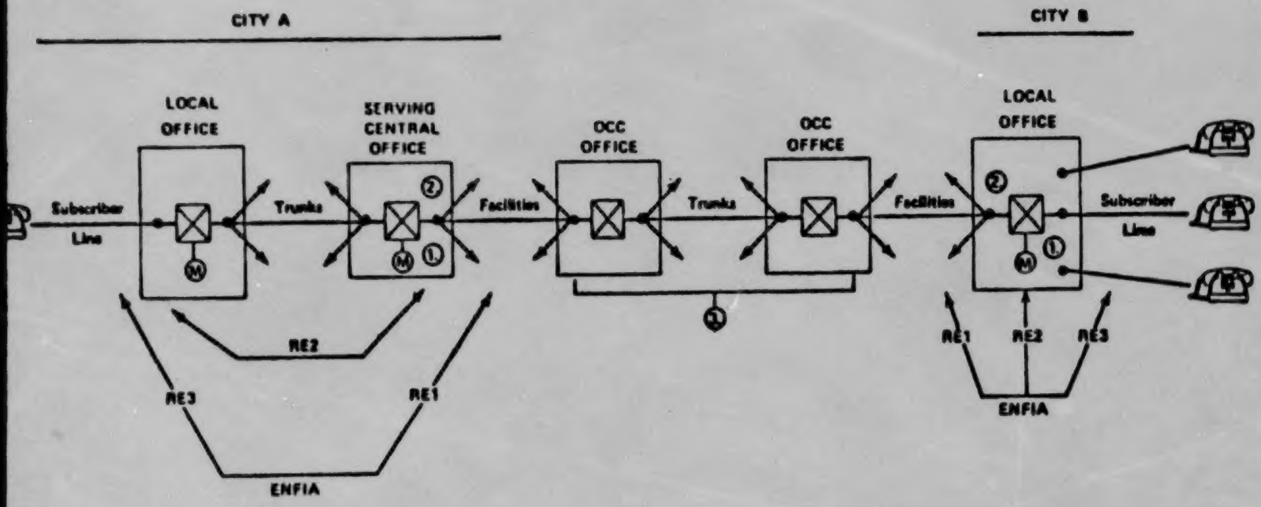
The toll switching machine has the built-in intelligence to determine the proper public switched network route and connects the call to a trunk to the desired distant toll switching office. The 10 digits are then forwarded to the distant toll switcher. The distant toll switching machine absorbs the first three routing digits; connects to a toll completing trunk to the local office serving the called subscriber; and forwards the seven digits of the called telephone subscriber to the local office. (The number of digits forwarded to the local office could be 4, 5, 6 or 7 depending upon the particular central office equipment configuration, but is usually 7.)

The local serving office switch connects the toll completing trunk to the subscriber line, rings the subscriber if idle or returns a busy signal if the line is busy. Upon answer by the called party, a signal is returned to the originating local serving office to trigger the AMA equipment to begin timing.

* The local area code.

FIGURE 6

EXECUNET AND SPRINT V


CITY A
CITY B
LOCAL OFFICE
SERVING CENTRAL OFFICE
OCC OFFICE
OCC OFFICE
LOCAL OFFICE
Subscriber Line
Trunks
Facilities
Trunks
Facilities
Subscriber Line
M
①
②
③
RE1
RE2
RE3
ENFIA
RE1
RE2
RE3
ENFIA

Notes: 1. Present Measured Exchange Lines Meter Outgoing Usage Only.
2. Line Side Termination For Facilities
3. The Precise OCC Routing Is Not Known

Source: AT&T Letter to FCC
September 28, 1978

EXECUNET and SPRINT V

The patron picks up his handset and receives dial tone from a local telephone office. He then dials the 7-digit telephone number of the exchange service subscribed to by the OCC.

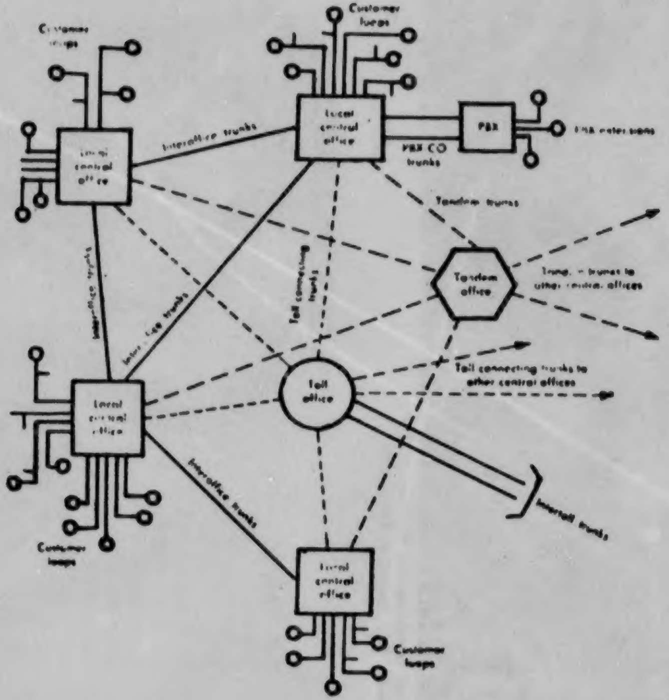
The local office switches the call via an interoffice trunk in the public switched network to the Telephone Company's central office serving the OCC. A switch in that central office switches the call to the facilities going to the OCC office and delivers ringing current to the OCC office. The switch in the OCC office automatically answers the call, sends an off-hook signal to the patron's local office and returns a tone to the patron. At this point, the patron inputs an authorization code and the 10-digit number required to reach the desired distant telephone subscriber.

The OCC carries the call, including the dial information to its distant office. The OCC distant office connects to a Telephone Company provided facility to the Bell local office, and forwards an off-hook condition to the Bell office, receives dial tone and automatically delivers either 7 or 10 digits to the Bell local office. 7 digits will be delivered if the call is going to a number in that NPA* and 10 digits will be delivered if the call is going to a number in a different NPA. Based on those digits, the local telephone switch connects the call through the public switched network to the called telephone subscriber line, rings the subscriber if idle, or returns busy signal if the line is busy.

* The local area code.

FIGURE 7

Exchange Area Plant


Customer loops
Local central office
Interoffice trunks
Customer loops
Local central office
PBX
PBX extensions
PBX CO trunks
Tandem trunks
Interoffice trunks
Toll connecting trunks
Tandem office
Tandem trunks to other central offices
Interoffice trunks
Toll office
Toll connecting trunks to other central offices
Local central office
Customer loops
Interoffice trunks
Intertoll trunks
Local central office
Customer loops

Source: Transmission Systems for Communications, p. 75, Bell Telephone Laboratories.

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tions within the existing AT&T/Bell toll hierarchy. As the narrative attached to these figures indicates, the customer is operationally indifferent to the configuration chosen, except for the local dial-in to the specialized carrier.

Moreover, from a technical point of view, both the specialized common carrier and the long lines company would appear similar at the class 4 toll office level. Each could interconnect at that level for completion of a circuit to the designated class 5 or local office. As Fig. 7 shows, this level at which interconnection would occur is also compatible with a definition of intraexchange service which encompasses the class 4 and 5 offices while interexchange service, also interconnecting at the class 4 office, is provided as a services network which is "parallel" to higher levels of the long lines toll hierarchy.

It would be necessary for all interexchange carriers to establish with the local operating (intraexchange) company specifications for the interconnection and method of operation. There are office and interoffice trunking schemes which may be used for connections of this type.

Trunking schemes between class 4 offices sometimes vary to meet different signaling and termination practices, depending on the type of switching equipment in the offices that are involved (e.g., Common Channel Interoffice Signaling for ESS4A offices). Also, there are other more sophisticated methods of interconnecting which might have to be considered by the specialized carrier. However, these are technical-operational problems which can be resolved to be compatible with the intraexchange - interexchange structure.

As noted earlier, the existing hierarchy requires traffic data to determine circuit quantities and facility arrangements. It is not unreasonable to expect that such data and planning can continue unimpeded within the proposed industry structure where, for example, both the operating company (intraexchange carrier) and the specialized carrier provide data for higher level toll switching and facilities as required. Similarly, such planning down through the hierarchy, with the local company, would occur with the long lines company and the specialized carrier. This information can be derived and resolved with those companies involved within the proposed structure in a manner similar to that now used for jointly owned facilities of existing telephone companies.

This overview of the current industry structure and operations appears to indicate the basis for compatibility with the proposed intraexchange - interexchange structure of operations. Where there are specific signaling, termination, and other interconnect or interface problems, they appear to be readily resolved in ways which are similar to those which now prevail. Moreover, where economic factors may impinge on local (intraexchange) companies, they may be offset by the local network access charges to be imposed equally upon all interexchange carriers with which the local companies interconnect. Alternatively, if any economic factors are evident on the interexchange side, they would appear to favor the existing network-system participants which would likely continue their current interconnecting arrangements with which the specialized carriers would have to interface.

Following is a selected list of publications which relate to the issues discussed above, from technical, economic and institutional viewpoints.

SELECTED PUBLICATIONS

Engineering and Operations in the Bell System, Bell Telephone Laboratories, Inc., 1977.

Notes on Distance Dialing, American Telephone & Telegraph Company, Engineering and Network Services Department, 1975.

Basic Telephone Switching Systems, David Talley, Hayden Book Co., 1969.

Fundamental Principles of Switching Circuits and Systems, American Telephone & Telegraph Company.

"National Telephone Network Transmission Planning in the American Telephone & Telegraph Company," IEEE Transactions on Communications Technology, Vol. COM-19, No. 3, June, 1971.

The Dilemma of Telecommunications Policy; A Preliminary Inquiry into the State of Domestic Telecommunications by A Telecommunications Industry Task Force, 1978.

The Economics of Regulation: Principles and Institutions, Vols. I and II, Alfred E. Kahn, John Wiley & Sons, 1970 and 1971.

Computers and Telecommunications, S. L. Matheson and P. M. Walker, Prentice-Hall, 1970.

The Domestic Telecommunications Carrier Industry, Parts 1 and 2, Staff Papers, President's Task Force on Communications Policy, 1969.

Transmission Systems For Communications, Revised 4th Edition, Bell Telephone Laboratories, 1971.

Economic Regulation, Innovation, and Theoretical Insights in Telecommunications--Recent Trends in the United States and Worldwide

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Abstract

Rapid progress in telecommunications technology is surveyed from the standpoint of recent political and structural changes in economic regulation, and of microeconomic theory applicable to regulation of telecommunications. The examples of domestic satellite systems and videotex are treated. The interaction of these developments in the United States, Europe, developing countries, and the Pacific Basin is surveyed and projected into the decade of the 1980s.

1. INTRODUCTION

The aim of this paper is to survey recent trends in the economic regulation of telecommunications, both in the United States and worldwide.

Three factors that have emerged largely in the last ten years have substantially changed the environment in which such regulation takes place, and have also affected the type and extent of that regulation. These factors are (1) increasing progress, sophistication, and variety in telecommunications technology and services; (2) increasing emphasis on competition, private ownership, and autonomous market forces in telecommunications, as opposed to government regulation, ownership, and management; and (3) new insights of microeconomic theory into questions touching directly on telecommunications regulation. These factors and their many interrelationships are reviewed in Sections 2, 3, and 4. Section 5 treats the effects of these trends on current telecommunications regulatory policy in a number of countries and regions, including the Pacific Basin. Section 6 develops the example of videotex. Section 7 proposes a synthesis and conclusions.

2. NEW TECHNOLOGIES AND SERVICES

Our interest in this paper is in the economic effects of new technologies and services, rather than in their engineering or physical properties *per se*. From an economic standpoint, one can evaluate the effect of technology by a production function. If q is the maximum level of a single output that can be obtained from levels $x_1,\dots,x_n$ of n inputs by a particular firm, then the firm's production function $f(\cdot)$ linking inputs to output can be given by

$$q = f(x_1,\dots,x_n).$$

A technological advance that allows more output from the same inputs, or the same output from lower input levels, might be represented by a different function $g(\cdot)$, where either $g(\cdot) < f(\cdot)$ for the same input levels; or where

$$g(x_1',\dots,x_n') = f(x_1,\dots,x_n) \text{ and } x_i' < x_i,\ i=1,\dots,n.$$

Alternatively, if it seems that more efficient production is due more to an overall change in knowledge or business conditions beyond the range and control of the firm than in the exact nature of the relationship between inputs and output, one might insert a multiplicative factor h in the production relation:

$$q = hf(x_1,\dots,x_n).$$

An increase in the value of h (perhaps over time at the annual rate r, so that $h = \exp(rt)$) could likewise give more output for given input without requiring a change in the essential way in which the production process takes place.

Recent developments in telecommunications technology are legion and well known. Optical fibers and communications satellites, for example, have increased network transmission efficiency. Digitalization, frequency re-use, packet switching, and other innovations have had similar effects. Developments in microprocessors have led increasingly to the availability of integrated terminal equipment, in which many telecommunications functions previously performed by the network are being taken over at the terminal stage. Indeed, the distinction between network and terminal equipment, as well as that between communication and data processing, is being progressively blurred, a process which has led to difficulties in the institutional, legal, and regulatory oversight of telecommunications.

Increasing variety and complexity of services, whether such services are possible through existing or newly developed technologies, is also an important factor in the telecommunications environment. Demand for new services, or increased demand for existing services, makes possible increased load factors for telecommunications capacity, thereby decreasing costs to users of all other services (assuming economies of scale exist). In addition, visible success of new services, in an economic environment of liberalized market entry and competition, is a continuing incentive for the development and marketing of even newer and more varied and sophisticated products and services.

While the above may appear familiar and commonplace, it bears repeating in a paper dealing with economic regulation. This is primarily because most regulated sectors of the economy, particularly in the United States and to a certain extent elsewhere, are generally those in which a static or even backward technology predominates--for example non-electronic postal services and railroads. Telecommunications is a striking counterexample, so much so that its effects over the next two or three decades may be comparable to those of the Industrial Revolution. The interactions, mostly positive, of a rapidly changing technology with an environment of quickly adapting and innovative regulation will be dealt with in the next section.

3. NEW PHILOSOPHIES OF REGULATION

Two polar paradigms of regulation will be sketched at the outset, and then applied to telecommunications in various countries.

3.1 TWO PARADIGMS

In the United States, railroads, canal companies, and telegraph lines of overwhelmingly private ownership were a significant force in developing and populating large parts of the country. Following a tradition of legislative establishment of regulatory bodies at the Federal level which began with the Interstate Commerce Commission in 1888, Congress created the Federal Communications (FCC) by the Communications Act of 1934. This, with modifications, has formed the basis of regulation of interstate and international telecommunications since that time. Intrastate telecommunications are by and large conducted under rules established by public utility commissions created by legislation in the various state legislatures. Rate-of-return regulation, based on limitation of profit to a set percentage of the rate base , or invested capital adjusted for depreciation, became the predominant single parameter of control and supervision.

The American telecommunications industry is currently characterized by private ownership. On the theory that a "natural monopoly" exists in the provision of most services, however, provision of network services is generally restricted to one monopoly firm. In return for a prohibition of competition, the monopolist is submitted to the scrutiny of a government regulatory body, which typically is charged by legislation with the task of assuring non-discriminatory access to the services provided at fair prices, where such prices are generally understood as those that give the monopolist a return on invested capital which is reflective of returns available in the economy at large.

The contrary paradigm is one of government operation and ownership of telecommunications facilities. This accurately reflects the situaton in most countries other than the United States, including the developing countries and the European countries. In the Federal Republic of Germany, for example, telecommunications sovereignty is vested by law in the Deutsche Bundespost, which is the largest employer in the country. Corresponding to the American concept of regulation is the German idea of Ordnung or Ordnungspolitik, which is difficult to translate into English. Ordnung can mean both "order" and the legislative and administrative steps taken to bring about order, or the orderly provision of services by the government. This concept has little to do with the economic concept of the invisible hand, which Adam Smith held to impose order autonomously on an unregulated, laissez-faire economic environment in which all agents pursue their own self-interest. Rather, it is a philosophical and political concept in which "order" is seen as the converse of disorder or, perhaps, chaos. The state is typically seen to have a unique ability to bring about order in the economic sphere and is therefore accorded necessary powers to do so in telecommunications and in other areas (1).

Thus, the dimensions in which deregulation or liberalization of government control of telecommunications can take place vary in the two paradigms outlined above. In the American model, liberalization cannot involve withdrawal of government in favor of private ownership and operation, since ownership and operation is already private. Rather, it can involve liberalization of conditions of market entry, decreased control over conditions of service, tariff policy, and so forth. In the second model, liberalization could involve all the above but also replacement of the state by private owners or operators of telecommunications facilities (corresponding to the German Entstaatlichung, or de-stating).

The United States is presently in an era of regulatory thought and practice which is promotive of deregulation of telecommunications and other regulated industries. One might speculate at length as to the sources of this trend. It is surley informed to come extent by the British tradition of liberalism descended through Adam Smith, Jeremy Bentham, and John Stuart Mill. More recently, American experience with largely failed social programs of the 1960s and 1970s has given strength to widespread disinclination toward government in general. Philosophically, the "subsidiarity principle" calls for government operation only in those cases for which it is demonstrably superior to private operation and ownership.

3.2 THE EXAMPLE OF SATELLITES

Whatever its sources, deregulation in the U.S. telecommunications sector has been of longer duration and more far-reaching than elsewhere, with the single exception of civil aviation (2). The first recognizable step occurred in 1962, with the passage by Congress of the Communications Satellite Act. The emergence of communications satellites into technical and commercial fruition in the early 1960s left open the question of ownership and operation of the American portion of the international system then being planned. The large U.S. international carriers lobbied to be given authority to own and operate the overseas satellite facilities, and won substantial congressional support. Another congressional faction favored government ownership and control, a departure from American practice that would have brought American participation in the international system into much closer coordination with that of its international correspondents (at the time, basically the European PTTs).

Pressure in the latter direction came not only from Europe and the carriers, but from the heady New Frontier optimism about government activism generated in the early months of the Kennedy administration. A compromise was struck, and the congressionally-chartered Communications Satellite Corporation (Comsat) that emerged was initially owned fifty percent by the overseas carriers and fifty percent by the public. One would be hard pressed, in view of the checkered subsequent regulatory history of Comsat, to deem its formative legislation as either deregulatory or salutary. It did, however, introduce diversity, both in services and in structure, into the telecommunications environment, and provided a sharper institutional focus for the new technology of satellites.

A clearer case of helpful deregulation in the telecommunications area is that involving U.S. domestic satellite systems. As early as 1965, the FCC began to receive applications from television networks, aerospace firms, and non-profit institutions for authorization to design, own, and operate domestic satellite systems. Yet toward the end of the Johnson administration, a Task Force on Telecommunications Policy (3) recommend housing all international telecommunications in a single monopoly entity (Comsat was recommended for this role); likewise, the Task Force recommended monopoly operation of domestic satellite communications. This report, however, became something of a dead letter with the entry of the Nixon administration a month after its publication. Early in 1970, a White House memorandum to the Chairman of the FCC urged careful consideration of competition in the provision of domestic satellite services. While the memorandum acknowledged the theoretical advantages of a monopoly supplier in the case of economies of scale, it also noted that the extent of such economies, if any, was unknown, and that even if they existed to an appreciable extent they might be outweighed by the advantages of innovation and variety of services to be expected by the competition of more than one supplier.

This policy document was translated into administrative action by the FCC's so-called "Open Skies" policy announced in 1973, after which a number of domestic satellite systems were launched and began operation, the first only a year later. Today, with many systems either in operation or firmly planned, retrospective judgment of the procompetitive approach is almost uniformly positive. While a small number of countries, notably Canada and Indonesia, acquired a single, broad, nationally operated satellite system as a matter of national policy (primarily for reasons of development and integration), others--in particular Australia and Japan--are resisting the urge for massive and possibly premature acquisition, and instead are working incrementally toward domestic satellite systems with primary emphasis on cost factors and users' needs. Finally, satellite needs at the domestic and regional level are also being met in other ways: (1) leasing of transponders from INTELSAT under favorable leasing tariffs first introduced in the early 1970s (Nigeria, Brazil, Norway, and many others); (2) regional satellite systems in varying stages of realization, none of which, however, are yet operational (Arab States, Africa, Europe); and (3) imaginative bilateral experiments and pre-operational projects, notably U.S.-Japanese and French-German initiatives.

Our excursion into philosophical foundations of regulatory outlooks and the role of the state, combined with the historical example of domestic satellite systems, has given some insight into the question of whether governmental or private ownership of telecommunications facilities is desirable. Another and somewhat independent dimension, however, is whether monopoly or some degree of competition is advisable, whether or not one of the suppliers happens to be a government authority. While it may seem unusual to speak, for example, of the case in which the postal authorities compete with private enterprise for customers in a particular telecommunications market, our discussion below of new trends in microeconomic theory will lay a foundation for evaluating the timeliness of such a possibility.

4. RECENT ADVANCES IN THE THEORY OF REGULATION

Drawing to some extent on earlier seminal work by Frank Ramsey and Marcel Boiteux, a group of economists centered at Bell Laboratories and Princeton University have added many new microeconomic insights to the theory of regulation during the past decade. Their contributions, indeed, are among the most significant since the development of imperfect competition theory during the 1930s. An extremely brief catalogue of the more important advances will be given below, with references for the interested reader.

4.1 ECONOMIES OF SCALE AND ECONOMIES OF SCOPE

The older concept of economies of scale has traditionally been the underpinning of justification for "natural" monopoly--average cost of output falls as the level of output increases. This concept, however, assumes that there is only a single output or service. The concept of average cost as conventionally defined becomes ill-defined for the firm with multiple outputs. A concept of multiproduct economies of scale (4) has been developed to fill this gap. The notion of product-specific economies of scale in the context of multiproduct output has also been formalized (5). Finally, the new concept of economies of scope has meaning only in the context of multiproduct production. Economies of scope (6) are defined to be present over a product set if for all non-trivial partitions of the product set it is cheaper to have one firm produce the entire range of products than to have each subset of products in the partition produced separately. As an example, a postal authority might be able to offer network and terminal equipment services more cheaply than would different suppliers (the post, say, for the network and private firms for the terminal equipment).

4.2 SUSTAINABILITY OF MONOPOLY

This concept applies to the case of a regulated monopolist required to offer a particular range of services and facing the possible market entry of competitors who may find it in their interest to offer only a subset of those services. A monopoly is called sustainable if there is at least one vector of prices for which the monopolist does not lose money in offering all the required products, yet for which any potential entrant would incur only losses in offering the same services, or any subset thereof, at lower prices (7).

4.3 INVERSE-ELASTICITY (RAMSEY-BOITEUX) PRICING

While pricing based on marginal costs has broadly applicable welfare-theoretic optimality properties, such a pricing regime fails to cover total costs for a regulated firm with economies of scale.

Taking price elasticity of demand (ability to pay) as well as marginal cost into account has been shown to be a welfare-optimizing way of making up the deficit in such a case (8). Specifically, the proportional deviation from marginal cost for each service is set to be inversely proportional to the price elasticity of demand of users for that service. Thus, highly price-sensitive (price-elastic) users are charged well below marginal cost, and highly price-insensitive (price-inelastic) users are charged well above marginal cost. The scale markup or reduction factor is set so as to just recover total costs.

4.4 NETWORK ACCESS CHARGES

Recent contributions (9) have suggested the compensation of regulated network owners by suppliers of services who, by regulatory decree, are awarded access to the network. Losses are otherwise incurred by the network operator who enjoys economies of scope, in that the entrant diverts traffic and thereby erodes such economies.

4.5 SUMMARY

This section has been little more than a lexicon of new concepts and directions in the so-called "sustainability" literature of recent years. Many important individual results have been obtained: for example, conditions under which Ramsey-optimal price vectors are sufficnet to guarantee sustainability of monopoly (10), or the result that it is possible to have economies of scope without economies of sclae, and vice versa (11). The burden of the sustainability literature has been that competition should be allowed in previously regulated monopoly areas only under very carefully defined and monitored conditions. It can serve as a theoretical buttress against an overzealous promotion, in the American context particularly, of competition and deregulation in telecommunications.

5. PRESENT AND FUTURE TRENDS

Telecommunications today stands in a bracing atmosphere of rapid technological change, development of highly pertinent microeconomic theory, and political and philosophical viewpoints supportive of steady institutional and regulatory innovation. The background in each of these developments has been sketched in the three preceding sections. We turn now to brief summaries of the effects of these developments on telecommunications in various parts of the world.

5.1 UNITED STATES

Massive changes in the telecommunications environment can be expected into the indefinite future. The American Telephone & Telegraph Company (AT&T), for example, while having its terminal equipment and (to a lesser extent) network monopoly eroded by regulatory decisions favorable to smaller firms, has now declared itself ready and willing to compete, perhaps through arm's-length subsidiaries, in non-regulated areas such as data communications (12) and electronic information markets (13). Satellite Business Systems (SBS), a joint venture of IBM, Comsat, and Aetna Insurance, will offer specialized business services beginning in 1982. The rewriting of the Communications Act of 1934 will drastically alter the regulatory environment, perhaps abolishing the FCC, establishing a Universal Compensation Fund to replace the present separation agreement for intra- and interstate traffic, and promoting competition everywhere but in local network traffic. The Uniform Compensation Fund would subsidize local networks and also particularly rural areas that might suffer under competition. In the best of worlds, the telecommunications consumers in the United States should be able to benefit substantially from broader and cheaper availability of increasingly sophisticated services; the economy at large will gain from the spinoff and multiplier effects of innovation and investment; and established firms such as AT&T should have the political and financial influence to find a place in the sun under the new arrangement. Correct use and appreciation of recent advances in microeconomic theory relating to the nature of sustainability of monopoly should prevent overzealous or uncritical excess in the dismantling of monopoly suppliers.

5.2 WESTERN EUROPE

France and Germany represent the prototypically centralized PTT-type approach to telecommunications. The United Kingdom is not too different from this pattern, but does vest much of its overseas telecommunications in the private firm Cable & Wireless. The smaller Western European countries are much the same as the former two, and can be expected to display more conservatism than the larger countries, following their lead.

Yet there is evidence that telecommunications liberalization and deregulation in the United States is at least giving pause and attracting notice. In Germany, for example, a rather uneven pattern of government and private provision of recent terminal equipment services is arising, with no overall policy yet agreed on by the Bundespost or national legislation. The Bundespost is the monopoly provider of the main telephone instrument; is a co-competitor in the provision of facsimile service and modems; and does not compete at all in offering telex or computer terminals. The Bundespost's role in the provision of facsimile service led to a lively public controversy and delayed the introduction of the service until early 1979. Recently, German economists specializing in telecommunications issues (14) proposed that the Bundespost compete with private suppliers of terminal equipment. This is a somewhat less comprehensive change than that suggested by the transport ministers of the German Länder, who had proposed a greater restriction of postal activity in terminal equipment. The economists also suggested an institutional separation of regulatory from entrepreneurial/operational activities of the Bundespost to prevent possible conflicts of interest.

While the future course of events in Europe is difficult to predict, it is clear that the increasing diversity, sophistication, and price attractiveness of American telecommunications equipment will cause some realization in Europe of the role of competition in upgrading the domestic telecommunications industry and in giving it incentives to produce equipment that can be competitive in export markets. Pressure for liberalization in Europe may well come from industry or from ministries other than the PTTs, but it is clear that the traditional role of the postal and telecommunications authorities will be carefully reconsidered in the larger European countries during the 1980s, perhaps within the context of the European Economic Community. Smaller European countries may be expected to follow suit, although those with no internationally competitive telecommunications equipment markets to defend may do so more slowly than those that have such markets. Examples of past European response to the "American challenge" have included successful and highly imaginative transnational aerospace consortia which bid for INTELSAT subcontracting, and perhaps less successful efforts by the European Space Agency (ESA) and its predecessors to construct and launch communications satellites as a counterpoise to American influence in INTELSAT.

5.3 JAPAN

Given its capacity for technological innovation, its felicitous labor-management relations, its strongly competitive position in export markets, and the ability of its government and industry to orchestrate coordinated national efforts for goals deemed desirable, Japan may be expected to allow telecommunications liberalization and competition to the extent it finds it desirable to do so. At present, there is not yet much movement in that direction, although KDD, its international monopoly carrier, has long been a private company. Characteristic of this flexibility is its approach to the use of domestic communications satellites, which has combined joint U.S.-Japanese experimental initiatives with national experimental and preoperational efforts favorable to full-scale domestic implementation. It is also a leader in optical fiber technology.

5.4 DEVELOPING COUNTRIES

There is little or no useful, comprehensive economic theory on the relation between telecommunications and economic development (15). Also, international organizations have policies toward telecommunications development which the LDCs consider either highly commercially oriented (World Bank) or limited and poorly funded (International Telecommunication Union). These factors together do not augur well for the responsiveness of the world telecommunications environment to the needs of LDCs. It is of course unclear whether liberalization of competition would be generally beneficial to these countries, given the low level of demand and lack of domestic telecommunications industry. A dependency on the industrialized countries may be increased rather than relaxed if present policies are followed.

5.5 THE PACIFIC BASIN

This geographically large and diverse area includes the United States and Japan, two telecommunications giants whose electronics, information processing, and telecommunications industries are locked in world-wide competition; Australia and New Zealand, two industrialized countries with small populations and little export orientation for telecommunications products; and a large number of developing countries in Latin America, Southeast Asia, and the Pacific Islands. Canada, while large and industrialized, has a moderate population, particularly in proportion to its size, and a hinterland that is still basically underpopulated and underdeveloped.

Development of new telecommunications services, and extension of international routes and traffic due to liberalization of telecommunications regulation, may well redound to the benefit of the developing countries in the Pacific Basin. Those with the most to gain might well be the small Pacific Island nations and communities, for whom geographical remoteness and poor telecommunications domestically and internationally constitute a major obstacle to economic progress. It is unclear, however, whether commercially and efficiency-oriented approaches in the industrialized countries will be to their benefit. Just as practically all industrialized countries, including the United States, subsidize telecommunications in their rural areas, the international community at large might wish to consciously subsidize telecommunications in the developing countries, both between sets of countries but particularly between the capital cities and the rural areas of LDCs.

6. VIDEOTEX SYSTEMS AS AN EXAMPLE

We have consciously refrained from reference to this vital new service in order to present it as an example to solidify and conclude our remarks. Videotex can be seen as an opening wedge of technological innovation and institutional and regulatory adaptation in industrialized countries long characterized by lethargy and lack of imagination in telecommunications. Here a type of competition has arisen in the wholly unregulated international environment. Systems developed by British (Prestel), German (Bildschirmtext), French (Teletel), Japanese (Captain) and Canadian (Teledon) telecommunications authorities have been and are continuing to be assiduously discussed, prepared, and promoted at the international level (16). As in the case of its domestic satellite program, the United States approach to videotex is relatively diffuse, decentralized, and responsive to market rather than governmental forces (17). Emergence of domestic markets for videotex at the rates currently being predicted will bring about telecommunications landscapes by 1990 which are quite different from those of today, at least in the terminal equipment sector.

7. CONCLUSIONS

We have examined three factors that will profoundly affect telecommunications during the 1980s--technological progress in telecommunications; new philosophical and political openness to competition and to regulatory and institutional innovation; and developments in microeconomic theory with important implications for economic aspects of telecommunications and regulation. The intersection of these three forces was examined both for the examples of domestic satellite communications (a process largely of the 1970s but one which is continuing) and of videotex (a development to take place largely in the 1980s). Likewise, effects generally of these trends were examined in a number of countries and regions.

If all goes well, these forces combined could have a most positive effect not only on the availability of increasingly varied, sophisticated, user-oriented, and low-cost telecommunications media and services during the 1980s and beyond in the industrialized world, but could also, with suitable attention and institutional innovation, vitalize the telecommunications infrastructure of developing countries and regions, including those in the Pacific Basin, as an engine for economic growth more generally.

8. FOOTNOTES

(1) See (10) for a comparison of the two approaches.

(2) See (1) for an account of airline deregulation. The author is presently a member of the Civil Aeronautics Board.

(3) See (14).

(4) See, for example, (12).

(5) Ibid.

(6) See (11).

(7) See (2).

(8) See (5) and particularly (13) for early works, and (3) for a more recent restatement of inverse elasticity pricing.

(9) See (15), for example.

(10) See (2).

(11) See (11).

(12) See (6).

(13) See (9).

(14) See (7).

(15) See (8) for the best available bibliography of literature on telecommunications and economic development.

(16) See (4).

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PROGRESS ON THE U.S. CIVIL SPACE POLICY

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ABSTRACT

Under Presidential Directive 42, Civil Space Policy, the National Telecommunications and Information Administration was given the lead to formulate policies designed to stimulate a new generation of commercial satellite service to meet public service needs. This paper identifies the results of the first year of NTIA efforts to fulfill this Presidential mandate. Emphasis is on describing NTIA's Dispersed Users Satellite program and showing its applicability to telecommunications issues being addressed in the Pacific Basin.

INTRODUCTION

A four year program to stimulate a new generation of commercial satellite services to meet public service needs has been mandated by Presidential Directive and funded by Congress. This program and related supportive activities are being implemented by the National Telecommunications and Information Administration (NTIA) within the Department of Commerce. This paper provides a brief overview of NTIA, explains the background, mission and primary activities of this new program created in response to the President's Civil Space Policy, summarizes the results of the first year of NTIA efforts to fulfill this Presidential mandate and details supportive program activities initiated by NTIA as follow-up to the February 17-20, 1980 Pacific Basin Development Conference. Emphasis is on identifying the roles of various first year NTIA grantees in supporting program objectives, providing examples of potential satellite services that may be provided and extending an invitation to members of the Pacific community to actively participate in this endeavor at the earliest possible time.

THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

The National Telecommunications and Information Administration within the U.S. Department of Commerce[1] is the principal Executive Branch agency advising the President on most of the issues relating to the two areas that compose its title.

As such, NTIA embraces a number of varied activities. It plays a major role in developing communications and information policy for the Executive Branch. It works to insure that this policy is effectively presented to the Federal Communications Commission, the Congress, and the public. It coordinates Government preparations for international telecommunications conferences and negotiations, and advises the State Department on appropriate aspects of international telecommunications and information policy.

NTIA also contributes to the management and the improved usage of the Government's vast telecommunications resources. For example, it assigns frequencies to Federal radio stations and establishes policies concerning the assignment and use of the Government's share of the radio frequency spectrum. It explores possible applications of telecommunications systems. It performs applied scientific and engineering research and analysis to improve our understanding of the technology. It coordinates Federal telecommunications assistance to State and local governments. And, together with the Office of Management and Budget, NTIA evaluates the procurement and management of telecommunications systems for the Federal Government.

In addition to serving as the Administrator of NTIA, the Assistant Secretary is the principal adviser to the President on telecommunications policies pertaining to the nation's economic and technological advancement and to the regulations of the telecommunications industry.

There are five major organizational elements within NTIA: Policy Analysis and Development, Federal Systems and Spectrum Management, International, Telecommunications Sciences and Telecommunications Applications. Although all program areas are participating to some degree in implementing the Civil Space Policy, the lead has been assigned to the Office of Telecommunications Applications with strong support from our Institute for Telecommunication Sciences (ITS) located in Boulder, Colorado.

DISPERSED USERS SATELLITE PROGRAM

In the Executive Order that established the NTIA in 1978, the Department of Commerce was charged with developing and setting forth "telecommunications policies pertaining to the Nation's economic and technological advancement" (EO 12046, Section 2-406). This charge was elaborated with regard to communications satellites in the Administration's Civil Space Policy, Presidential Directive (PD) 42. In that Directive, NTIA was given three interrelated missions: (1) to aggregate the potential public service users of communications satellite services; (2) to stimulate research and development of inexpensive satellite technologies and services appropriate to the low-volume public service users; (3) to translate the agency's experience in market aggregation and R&D into programs for lesser developed countries. These three missions form the cornerstone of the Dispersed Users Satellite Program, administered by NTIA's Office of Telecommunications Applications (OTA).

The Federal Government has long been committed to satellite communications and to the growth of a vigorous commercial satellite industry. That industry has benefited greatly from government-funded R&D efforts, such as those of the Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA), and indeed has emerged to serve domestic and international needs. However, the existing commercial systems have not developed satellite technologies and services appropriate to large portions of the public service sector. They are presently designed to serve high-volume, geographically centralized communications users in major urban areas. In contrast, many public service users have short-term, intermittent, and low-volume communications demands, commonly referred to as 'thin-route' traffic, among dispersed agencies and offices. Available commercial technologies are not compatible with the inexpensive satellite ground systems essential to serving many rural areas and decentralized agency users. Public service users with low-volume, intermittent communications needs cannot afford the sophisticated and expensive systems now in use, nor is it considered profitable by the commercial carriers to launch high-power satellites to serve this community. Where available technology could be used, service to this disaggregated market has not proven to be a profitmaking venture, and therefore commercial carriers have not offerred to the public sector the benefits that distance-insensitive communications satellites could provide.

In this environment, the Dispersed Users Satellite Program, with authority conveyed by PD-42, was created to fill the gap in the commercial market by acting as a catalyst in developing a new generation of commercial services to meet public service needs. To pursue activities consistent with its role as catalyst, the Program has developed a four-year plan and, for Fiscal Year 1980, was given granting and contracting authority totaling nearly $1.5 million. The major activities of the program reflect its three missions--market aggregation, technical studies of relatively inexpensive technologies, and international applications.

Market Aggregation

To fulfill this goal, NTIA announced several grants supporting the program. Included are grants to four "brokers" to establish communications networks using commercial satellites for public service education and training services. Financial support by for these brokers (two non-profit firms and two for-profit firms) and any brokers subsequently chosen will be phased out over varying periods of time. All financial support for all brokers will terminate no later than the fourth year of the program. Success of these brokers and confirmation of the underlying approach of this portion of the program will be measured by the existence of such economically viable commercial entities meeting the communications needs of public service groups through satellite technology.

The four grantees are:

1. The Appalachian Community Service Network. ACSN will expand its currently operating satellite/cable network, which offers instructional programming primarily in the Appalachian Region, to include national public service applications. This builds upon past Federal commitment to transfer this activity from a NASA experiment to a commercial operation.

ACSN provides 35, and soon 60 or more hours of programming a week, and we expect their service to reach 1 to 2 million homes within a year. Network services include use of an available uplink located in Lexington, Kentucky, transponder capacity, technical and engineering support and other services assisting users such as identification of needs, requirements, schedules, costs and service impacts.

2. Bell and Howell Company. Bell and Howell, an international manufacturer of audio-visual hardware, is developing a Civic Affairs Network linking multiple locations through satellite earth stations. The network will be used by public service organizations and government agencies for training, education, teleconferencing and community outreach.

This Civic Affairs network will have an up-link in L'Enfant Plaza, Washington, D.C. There a full teleconferencing studio will be built and, if schedules hold, should be in full operation by the time the 1981 Pacific Telecommunications Conference convenes. Nationwide there will be ten downlinks, including Atlanta, Boston, Chicago, Dallas, New York, Philadelphia, San Francisco, and Seattle. A new city will be added every second month until the Civic Affairs network is completed.

3. The Public Service Satellite Consortium. PSSC is a national telecommunications organization composed of about 100 non-profit entities and an experienced staff of communications experts. PSSC's satellite uplink, mobile facility,

and other resources will be better utilized both by PSSC alone and in collaborative efforts with other grantees.

4. American Educational Television Network. AETN is a new for-profit corporation which has reserved space on an RCA satellite to transmit specialized continuing education programming to members of professional associations and employee organizations, helping to meet state licensing and college credit requirements.

In support of the four brokers, NTIA has awarded a fifth grant to the National Training and Development Service (NTDS) for state and local government to develop a strategy for information dissemination about the opportunities of telecommunications technology, especially satellite, to state and local governments and public service agencies.

As the training arm of the Academy for Contemporary Problems, NTDS serves as the information clearinghouse and training service for its parent organizations in meeting the training needs of their members. Its parent organizations are the seven major national organizations of state, county and municipal officials: Council of State Governments, International City Management Association, National Association of Counties, National Conference of State Legislatures, National Governors' Association, National League of Cities and the U.S. Conference of Mayors.

The potential market for the services to be provided by the brokers needs information not only on the services to be provided but on how individual agencies can take advantage of telecommunications technology in addressing their communications needs, particularly training requirements. NTDS is outlining and implementing a strategy for informing the potential market, assessing their communications needs, beginning an exchange of ideas among agencies and introducing our brokers and potential users of their service.

Localities can realize significant costs advantages by using state, regional or national communications networks such as are offerred by our brokers. These networks provide not only one-way video programming through uplinks and inexpensive satellite receive only ground terminals supported by one or more uplinks and two-way audio connections that let conference attendees ask questions of speakers providing the video presentations. Cost advantages come via aggregation. For example, if a 40 hour training course costing $20,000 is provided nationwide over a satellite transponder costing $500 per hour, the total cost is $40,000. If 100 cities use the material, each city would have to pay only $400. This assumes a local cable operator carries the service without additional change on the local cable system. A city manager can then offer the course to police officers at each precinct and firemen at their stations, saving local transportation costs and time away from work. On-the-job training of the highest caliber becomes easily affordable with these networks, if we can aggregate state and local training requirements. Similar types of networks and services are being provided or can be arranged by the four brokers.

Technical Studies

Existing commercial services, even if made available to the public sector through successful aggregation efforts, may not fully satisfy public service needs. New technology development may be required to provide very low-cost services for part-time users. Since the President's Directive assigned to NASA responsibility for undertaking R&D in public service satellite technologies, the Dispersed Users Satellite Program has deferred to NASA's experience and expertise. In addition, the Program relies on the support of the Institute for Telecommunication Sciences (ITS) within NTIA to carry out technical studies. The efforts of ITS focus on developing technical means to improve the efficiency and cost effectiveness of service and on providing a technical base for the development of policies to encourage the evolution of new satellite communications technologies with significant public service benefits. Specifically, ITS is defining options for the application of low-cost, small antenna earth stations, developing plans for orbit/spectrum utilization, and conducting studies of advanced ground terminal systems for rural areas and other thin-route services.

International Applications

The international mission given to NTIA under PD-42 began with Fiscal Year 1981 funds. Prior to that funding, collaborative relationships with the Agency for International Development (AID) of the Department of State and with the Department of the Interior were established. As one result of these relationships, ITS is providing technical support to AID in its rural satellite program. This program will provide basic telephone, radio broadcasting, and other narrowband services to remote areas of lesser developed countries. Support is being offered in four areas: thin-route telephone switching, low-cost converters, slow-scan television, and solar-powered ground facilities. Potential applications of these and other satellite technologies in rural development include health and nutrition, agriculture, education and training, and community development.

THE PACIFIC BASIN, DOC AND NTIA

The Department of Commerce is an active member in a partnership designed to help determine the future development needs and priorities of the American Pacific Islands. This partnership consisting of four Pacific island jurisdictions (the Territory of American Samoa, the Territory of Guam, the State of Hawaii, and the Commonwealth of the Northern Marianas), the private sector and the Federal Government, was formalized at the Pacific

Basin Development Conference[3] held in Kiulima, Hawaii on February 17-20, 1980.

The framework for this conference was based on a recommendation made by an Interagency Task Force on Territorial Policy, established in January, 1979. The Task Force recommended careful coordination of all Federal involvement in territorial development.

Responding to this recommendation, the Western Governors' Conference at their annual meeting in June of 1979 unanimously endorsed the concept of a Pacific Islands economic development conference. The Island Governors, Peter Coleman (American Samoa), Paul Calvo (Guam), George Ariyoshi (Hawaii), and Carlos Camacho (Northern Marianas), then requested and secured the active support of the Carter Administration through Department of Commerce sponsorship of the Pacific Basin Conference. The Conference explored development opportunities in the areas of fisheries, ports, trade, transportation, tourism, telecommunications, energy and the use of vast resources of the land and sea. The conference brought together the Island Governors, as well as representatives of the White House, Congress and various Federal, State and Territorial officials, with representatives from the business community, academia, labor and the military.

I have personally been associated with the Pacific Basin effort since the summer of 1979, and, naturally, have concentrated on the telecommunications issues. The goal of the telecommunications effort was to create a five-year regional plan that considers the individual and collective telecommunications needs of the Pacific Basin Islands - toward the establishment of a more complete and reliable telecommunications system.

The conference recommendations concerning telecommunications are three.

1. Take immediate action to assess the need for a Pacific Basin communication satellite.

2. Implement a process of assisting Island people to assess and meet their local telecommunications needs.

3. Establish a Pacific Island telecommunications regulatory and advisory service.

A key element in meeting these recommendations was a regional telecommunications requirements study. OTA has funded two efforts to initiate a follow-up to these conference recommendations.

In a cooperative interagency effort NASA and OTA are jointly funding PSSC to perform a twelve month study of Pacific Basin telecommunications. This study consists of three segments: a description of present telecommunications capabilities, a description of requirements to improve present capabilities, and a description of options for implementing improvements. NTIA is funding Future Systems Inc. to examine alternative costing and pricing approaches for a typical Pacific Basin thin-route network using the INTELSAT space segment. Both of these efforts can be described as germinal in nature relative to the telecommunications issues of the Pacific, and represent resources focused on an area of continuing concern to NTIA.

SUMMARY

This paper has provided an overview of NTIA and concentrated on a detailed description of the Dispersed Users Satellite Program within its Office of Telecommunications Applications. Although this program has among its Presidential mandates the aggregation of potential public service users of communications satellite services, is applicability to issues raised in the February 17-20, 1980 Pacific Basin Development Conference were emphasized. A continued interest in following up Pacific Basin telecommunications issues has been demonstrated, and members of the Pacific Basin and all attendees to the Pacific Telecommunications Conference are invited to participate in efforts to meet the goals of the Dispersed Users Satellite Program by utilizing the services of the brokers and/or providing inputs or feedback to the contractors described.

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RATE BASE VALUATION AND ITS
EFFECT ON THE RATE-OF-RETURN

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ABSTRACT

The process of public utility regulation has been intensively studied in recent years. Among those studies was work by Petersen [7]. Petersen showed that, contrary to expectations, state regulatory commissions operating under a fair-value philosophy were making rate-of-return decisions significantly more liberal than commissions using an original cost rate-base design. On an adjusted basis, the rates-of-return should be the same regardless of how the rate base is valued.

This paper examines this question for 251 rate cases decided between 1972 and 1977. Again the same liberal behavior is observed. However, the magnitude of these liberal returns is significantly greater than the returns observed by Petersen.

The Regulatory Process

Traditional public utility rate-making is done in two broad steps. First, regulatory commissions, after hearing evidence, determine the authorized total revenue requirement. Having derived this dollar figure, the prices for various offered services are developed so that, hopefully, the total authorized revenue is achieved [5, pp. 44-46].

The composition of the total revenue requirement is given in (1) below:

$$TR = OE + d + t + r\,(A - D) \qquad (1)$$

where: TR = total authorized revenue
OE = allowable operating expenses
d = annual depreciation expense
t = taxes
r = authorized rate of return
A = gross value of the assets
D = accumulated depreciation
(A-D) = "the rate base"

Obviously many issues are involved in arriving at values for each of the independent variables. However, rate cases in recent years have focused primarily on rate of return, r, and rate base valuation, (A - D).

Rate base valuation was for a long period the subject of vigorous court debate. As early as 1898, the Supreme Court declared that valuation should consider not only historical cost, but also weight should be given to reproduction cost [10]. The result is called fair value, and its use attempts to compensate utilities for inflation.

Subsequent to the 1898 Symth vs. Ames decision, the Court prescribed various weightings between historical and reproduction costs depending upon the level of inflation. However, in the 1930's, the Court felt that its proper function was not to be a board of revision [6]. This position was made explicit in the 1940's in the Natural Gas Pipeline and Hope Natural Gas cases [3,4]. In these cases, the Court said that its function was not to require regulatory commissions to use particular formulas or methods, but rather to insure that the end result of a rate case is reasonable. If the authorized total revenue is sufficient to recover operating and capital costs, then it is irrelevent whether a commission authorizes a low return on a large rate base or a high return on a low rate base [1, p. 351].

In application, most commissions have opted for historical rate base valuation. The form of historical cost used is original cost which is the price paid for an asset when placed in service by the first owner. The advantage of the method is obvious: original cost is easy to apply and objective since it is derived directly from accounting records. Some commissions, however, have elected to maintain fair value.

Whichever method is used, original cost or fair value, the associated authorized rate of return must allow the firm to maintain financial integrity (i.e., protect its credit rating), attract capital and compensate investors for risks assumed [3]. If commissions are efficient, then the high return granted on an original cost rate base

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should be equivalent to the lower return granted on a fair value rate base. That is, fair value returns should not be excessive relative to original cost returns.

Petersen, in a 1976 paper tested this hypothesis [7]. His conclusion is that when the authorized rates-of-return on fair value rate bases are adjusted to an original cost basis, the hypothesis is false:

> "As the fair value rate base is increased in relation to original cost, the allowed rate of return increases" [7, p. 1489].

The end result between original cost and fair value jurisdictions is not the same.

Unfortunately, the Petersen work was outdated at publication. The study examined only fifty electric utility rate cases decided between January 1969 and December 1971. Since the cases were pooled into one sample, any intraperiod changes in the relationship are not disclosed.

The objective of this paper is to first update the Petersen study by examining the fair value - original cost authorized rate-of-return relationship between 1972 and 1977. Second, the paper tests how rapidly regulators responded, period-by-period to the economic environment.

The null hypothesis is that rates-of-return authorized in fair value jurisdictions should be equivalent to rates-of-return granted in original cost jurisdictions. If the null hypothesis is false, then commissions using fair-value are either more or less generous than commissions using original cost. This would be the case since the method of rate base valuation is established, usually on a state-wide basis, before rates-of-return are decided in individual cases.

Data and A Historical Perspective

Data for this study is drawn from two hundred and fifty-one electric utility rate cases decided between January 1, 1972 and December 31, 1977. One hundred and ninety-four cases were in original cost jurisdictions and the remaining fifty-seven in fair value areas.

The 1972 through 1977 period was a time of dynamic change for the electric utility industry. Raw energy prices surged. Government first promoted environmental protection by encouraging utilities to switch to oil, then switch away from oil. Consumers became more active in the rate-making and plant approval process. Regulatory lag became a significant problem and energy relief, long promised by nuclear technology, was not realized. All of these problems were compounded by inflation and its effect on the cost of new plant and financing.

In addition to these changes, two significant events impacted the industry. First, oil was embargoed in October 1973. Second, Con-Ed omitted its quarterly dividend in April 1974. The results were declining equity prices, an upward shift in the industry's business risk and much greater media attention paid to the regulatory process.

To facilitate an examination of how rapidly commissions responded to these charges vis-a-vis authorized rate-of-return, the sample is divided into 11 subperiods, suggested by Pettway [8]. Figure-1 shows these subperiods and Exhibit 1 details the number of cases by subperiod.

Data is taken from the FPC/FERC Statistics of Privately Owned Electric Utilities in the United States [2], Statistical Abstract of the United States [11], and the Public Utility Reports [9]. In cases which where rate orders were not reproduced in the PUR, copies of the dockets were requested directly from companies involved. The data and the variables utilized are discussed in the following section.

Methodology

The methodology is two parts. First the rate-of- return rate base relationship is measured for each subperiod described above. Next, how rapidly these relationships change over time is examined.

To preserve continuity with Petersen's study, his methodology is used:

$$ROR = Bo + B1\ (FVOC) + B2\ (COC) + B3\ (GROWTH) \qquad (2)$$

where:

ROR = the authorized rate-of-return adjusted to an original cost rate basis
FVOC = fair value as a percentage above original cost
COC = a cost-of-capital measure
GROWTH = the percentage change in state population over the 10 years prior to the rate case

The ROR in original cost jurisdictions is the rate-of-return authorized by the commission. In fair-value jurisdictions ROR is adjusted to an original cost basis by multiplying the authorized return by the fair value original cost ratio. This ratio, expressed as a percentage in FVOC, is developed through a docket by docket search of rate cases. The dockets in fair-value areas most always contain an original cost figure and the commission's determination of fair value. (In original cost jursidictions, FVOC is equal to one.)

Unadjusted authorized fair-value rates-of-return are always less than original cost rates-of-return. This relationship is true because of reasons discussed earlier. That is, only the end result is relevant and a low return on a fair value rate base should produce the same revenue requirement as a high return on an original cost rate base.

B1 tests this hypothesis that original cost returns and adjusted fair value returns are equivalent. One of three outcomes is possible:

(1) If the adjusted fair-value rates-of-return are less than the original cost rates-of-return, then as FVOC rises, ROR falls. The B1 is negative and fair-value returns are deficient relative to original cost returns.

(2) If the adjusted fair-value rates-of-return are the same as original cost returns, then as FVOC rises, ROR remains the same. Hence, B1 is zero and the benefits of fair valuation for rate bases are exactly offset by lower authorized returns. There is no advantage, from the firm's viewpoint, of fair valuation.

(3) If adjusted fair value returns are greater than original cost returns, then as FVOC rises, ROR rises and B1 is positive. Fair-value commissions have authorized excessive returns relative to original cost commissions.

COC is a cost of capital measure and is the weighted average of the cost of equity and embedded debt. To enhance comparison with Petersen's earlier work, the cost of equity is based on the earnings-price ratio of the stock in the year of the rate case. Since cost of capital underlies the rate-of-return, B2 should have a value of one.

The final independent variable, GROWTH, reflects the commission's willingness to support the financial integrity of firms experiencing rapid expansion. If commissions do acknowledge this expansion, then B3 should be positive.

The second step in the methodology is to test the extent and speed of adjustment by commissions to changing events. Of particular interest is how rapidly the riskless authorized rate-of-return changes [i.e., the intercept in (2)], and whether there is parity between fair-value and original cost jurisdictions. If commissions responded rapidly to the increasing inflation of the 1970's, then the intercepts should be rising period by period. If fair-value and original cost commissions are consistent over time, then the B1's should be the same period by period. The existence of significant differences between adjecent period coefficients Bo and B1 tests these hypotheses.

Results

Exhibit 2 shows the regression results for the eleven individual and pooled subperiods. The B1's are most always positive and significant indicating a false null hypothesis. On an adjusted basis, fair value commissions are more generous with regard to authorized rates-of-return than original cost jurisdictions. The pooled samples show that this generous amount ranges from 5.146 to 5.65 hundredths of a percentage point.

A surprising result is that the cost of capital coefficient, B2, is rarely significant. However, the signs are generally correct which indicates some positive tendency between the cost of capital and rate-of-return.

The growth coefficient, B3, is usually insignificant. There is a tendency for rapid growth to result in higher authorized returns, but the relationship does not become strong until after 1975.

How rapidly authorized rates-of-return adjust to a changing environment is shown in Exhibit 3. It appears that the response to inflation occurs over widely separated periods. The t-values for the intercept show adjecent period returns to be about the same or declining. However, when early intercepts are compared with later intercepts (i.e., 1972 and 1973 vs. 1976 and 1977), significant increases are observed.

The fair-value - original cost return premium measured by B1 reveals a different pattern. Although there is a consistent tendency for fair-value commissions to be generous, there is also an up and down pattern from period to period. Only the first half of 1975 shows a significant increase over other periods.

Conclusions

The study supports Petersen's earlier work. During the 1970's fair value commissions were more liberal with respect to rate-of-return than original cost commissions. Therefore, utilities in fair value jurisdictions are better protected from inflation. This conclusion also holds for gas and telecommunications firms since commissions generally apply the same valuation technique to all companies they regulate.

Very little short-run impact on authorized returns from major economic and political events is observed. Over the long-run authorized returns did respond to changing conditions. By the mid 1970's the excess returns granted by fair-value commissions were signficantly greater than the excess returns observed by Petersen during the early 1970's (See Exhibit 4).

If utilities in fair-value jurisdictions initiate rate cases more frequently than companies in original cost areas, then the observed returns will be biased upward and excess returns will be observed. If this hypothesis is true, then the conclusions in this study are in question.

To test this hypothesis, the number of days between rate case filings on a company by company basis were observed for the 1975-1978 period. The results below show no significant difference in the frequency of filing between original cost and fair value areas and do not support the hypothesis:

Jurisdiction	N	Average Days Between Filing	S.D.	T-Value
Orig Cost	38	463.8	197.7	.826
Fair Value	25	512.9	273.5	

Finally, it should be mentioned that even though fair value returns may be "excessive" relative to original cost returns, these results do not imply that either are sufficient. It is quite possible that because of regulatory lag or attrition, returns authorized under both systems may not be in equilibrium with risk. Also, the focus of this paper has been on commission behavior. Realized return was not examined, but is properly the subject of subsequent work.

Footnotes

1) This relationship was tested using a two-sample t-test. For the 251 observations, the mean original cost and unadjusted fair-value authorized returns are 8.68% and 6.83% respectively. The t-value between means is 13.21 with 249 degrees of freedom, and it is concluded that the three possible outcomes described for B1 are feasible.

2) Assume that on the average authorized fair value returns are 7% and authorized original cost jurisdiction returns are 12%. Also assume that on the average fair value rate bases are 1.75 times original rate bases. This situation would mean that the adjusted fair-value return is 12.25% (7% x 1.75) and indicates an excessive return relative to the original cost return of 12%. Hence, B1 would be positive.

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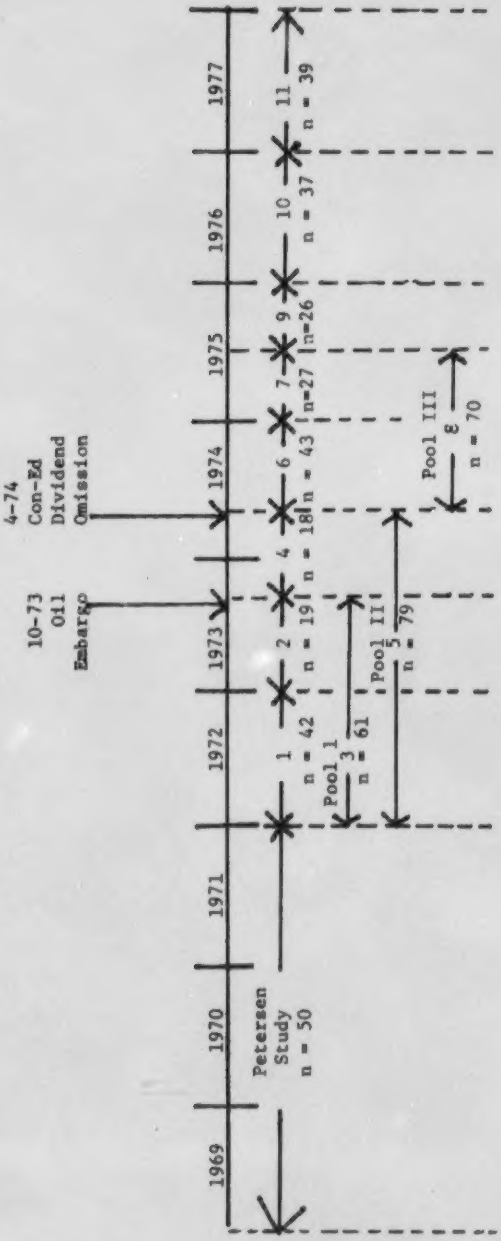
1969
1970
1971
1972
1973
1974
1975
1976
1977
Petersen Study n = 50
1 n = 42
2 n = 19
4 n = 18
6 n = 43
7 n=27
9 n=26
10 n = 37
11 n = 39
Pool 1 3 n = 61
Pool II 5 n = 79
Pool III 8 n = 70
10-73 Oil Embargo
4-74 Con-Ed Dividend Omission

FIGURE 1
THE SUBPERIODS USED IN THE STUDY

EXHIBIT 1
SAMPLE PROFILE

Subperiod	Sample Size	Original Cost Cases	Fair Value Cases
Petersen's Study Jan. 1979-Dec. 1971	50	32	18
1. 1972	42	30	12
2. 1973 to the October oil embargo	19	15	4
3. Pool I, 1972 + 1973 to oil embargo	61	45	16
4. 1973 after the embargo + 1974 to Con-Ed dividend default, April	18	10	8
5. Pool II, 1972 + 1973 + 1974 to Con-Ed	79	55	24
6. 1974 after Con-Ed (May-December)	43	28	15
7. 1975, first half	27	23	4
8. Pool III, 1974 after Con-Ed + 1975, first half	70	51	19
9. 1974, second half	26	20	6
10. 1976	37	33	4
11. 1977	39	35	4
Totals*	251	194	57

*(excluding Petersen's study)

EXHIBIT 2

REGRESSION RESULTS

	Intercept (T-Value)	B_1 Fair Value-Original Cost-Percentage (T-Value)	B_2: Cost of Capital (T-Value)	B_3: Growth (T-Value)
Petersen's Study Jan. 1969-Dec. 1971	2.6365** (2.46)	.0358** (4.33)	.1779* (2.09)	.0142** (3.38)
Subperiod				
1. 1972	7.0407** (7.586)	.0569** (7.670)	.0671 (.431)	.0184 (1.846)
2. 1973 to oil embargo	9.4132** (4.094)	.0341 (1.230)	-.2052 (.565)	.0037 (.152)
3. Pool I, 1972 + 1973 to oil embargo	7.3413** (7.775)	.05146** (5.958)	.0569 (.369)	.0126 (1.214)
4. 1973 after embargo + 1974 to Con-Ed	6.620* (2.907)	.0442** (4.380)	.2548 (.709)	.0063 (.338)
5. Pool II, 1972 + 1973 + 1974 to Con-Ed	6.849** (8.594)	.0518** (7.919)	.1540 (1.191)	.0125 (1.378)
6. 1974 after Con-Ed	6.075** (4.607)	.0203 (1.699)	.3423 (1.785)	.0234 (1.570)
7. 1975, first half	7.349** (6.325)	.0745** (11.02)	.1881 (1.23)	Not entered
8. Pool III, 1974 after Con-Ed + 1975 first half	6.261** (7.530)	.0565** (8.000)	.3136* (2.580)	.0102 (1.169)
9. 1975, second half	10.006** (8.981)	.0308** (3.557)	-.1372 (.915)	-.0069 (.640)
10. 1976	8.381** (10.352)	.0187 (1.623)	.0232 (.477)	.0456* (2.189)
11. 1977	7.215** (12.654)	.0348** (4.647)	.2209** (3.099)	.0185* (2.603)

* Significant at .05 level
** Significant at .01 level

EXHIBIT 3

STRUCTURAL TESTS OF THE 1972-77 REGRESSIONS

Test Number	Periods Tested	Degrees of Freedom	T-Value: Intercept	T-Value: Fair Value-Original Cost Coefficient B_1
1	1 vs. 2	57	5.811**	-5.039**
2	Pool 1 vs. 4	75	-2.000*	-3.018**
3	Pool II vs. 6	118	-4.047**	-18.878**
4	6 vs. 7	66	4.113**	21.440**
5	9 vs. 10	59	-6.717**	-6.735**
6	10 vs. 11	72	-7.290**	7.261**
7	Pool II vs. Pool III	145	-4.404**	4.217**
8	Pool III vs. 10	103	12.656**	-21.052**
9	Pool III vs. 11	105	6.367**	-15.051**
10	Pool II vs. 9	101	15.818**	-13.078**
11	Pool II vs. 10	112	9.602**	-19.033**
12	Pool II vs. 11	114	2.558**	-12.657**
13	Pool I vs. 11	96	-.0751	-9.893

* Significant at .05 level
** Significant at .01 level

EXHIBIT 4

FVOC STRUCTURAL TESTS OF PETERSEN's 1969-1971 SAMPLE AND LATER REGRESSIONS

Period Tested	(D.F.)	T-Value: Fair Value-Original Cost Coefficient
Petersen vs. 1972	(88)	12.772**
Petersen vs. Pool I	(107)	9.688**
Petersen vs. Pool II	(125)	12.207**
Petersen vs. Pool III	(116)	14.740**
Petersen vs. 1976	(83)	-8.068**
Petersen vs. 1977	(85)	.0590

* Significant at .05 level
** Significant at .01 level

Satellite Communication in Presence of Multipath Fading

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Abstract

The aim of this paper is to study the performance of a Satellite Communication System in multipath fading environment. The conclusions drawn from this study are beneficial for the transfer of telemetry and Command data between a space craft and ground station.

1. INTRODUCTION

The age of space communication has brought a wide variety of tele-services. The methods employed for the transfer of telemetry and command data between space craft and ground stations have become predominated by the use of uncoded binary symmetric channels and the techniques of implementation which have attempted to optimise such systems. These communication system consist of a serial binary data link wherein information is transmitted and detected in bi-orthogonal sense. The binary PSK system utilises the above basic principle. It is already established that multipath channels, comprising of more than six distinguishable paths, can conveniently be represented by a channel, which varies with the amplitude of the signal according to Rayleigh distribution and uniform phase. The aim of this paper is to establish the performance characteristic of above system when fading channel is multipath fading type, in terms of probability of error.

2. SYSTEM CHARACTERIZATION

The set up consist of a binary coherent PSK system with signal rate of 1/T where T is the signal bit period and carrier frequency ω_o. The receiver filter is assumed to be linear and time invariant with complex response $h_r(t)$. The channel characteristics are assumed to be linear but varying randomly. Hence it may be assumed to be time varying with impulse response $h_e(t,\tau)$. It is assumed that the signal being observed at the modulator output takes the form

$$S_m(t) = \sum_{i=-\infty}^{\infty} |A\, U(t-i\tau)\cos(\omega_o t+\theta_i)| \tag{1}$$

which corresponds to

$$S_m(t) = A \cos|\omega_o t + \alpha\left\{t,(A_i)\right\}| \tag{2}$$

where the instantaneous phase deviation $\alpha\left\{t,(A_i)\right\}$ is defined as

$$\alpha\left\{t,(A_i)\right\} = \sum_{i=-\infty}^{\infty} U(t-iT)\theta_i \tag{3}$$

If L(t) is the random time variant channel attenuation and B(t) is a random process representing the multipath fading, then

$$L(t) = 1 + B(t) \tag{4}$$

The fluctuating component of the signal $x_r(t)$ is given as

$$x_r(t) = \left\{B(t) \cos\ \omega_o t+\theta+\xi(t)\right\} \tag{5}$$

The probability density of B(t) is Rayleigh distribution and that of (t) is uniform distribution, i.e.

$$\begin{gathered} P(B) = -\frac{B}{\sigma_B^2} \exp|-B/2\sigma_B^2| \\ P(\xi) = \frac{1}{2\pi} \end{gathered} \tag{6}$$

σ_B^2 is the signal power in the fluctuating component can be rewritten as

$$x_r(t) = x'_{rc} \cos(\omega_o t+\theta) - x'_{rs} \sin(\omega_o t+\theta) \quad (7)$$

where x'_{rc} and x'_{rs} are independant Gaussian distributed random processes with zero mean and σ_B^2 as variance.

3. ANALYSIS

The output of the receiver filter can be expressed in the form

$$y(t) = |A + x_{rc}(t) + n_c(t)| \cos(\omega_o t+\theta)$$

$$- |x_{rs}(t) + n_s(t)| \sin(\omega_o t+\theta) \quad (8)$$

$$= y_c(t) \cos(\omega_o t+\theta) - y_s(t) \sin(\omega_o t+\theta)$$

or

$$y(t) = V_t \cos \omega_o t + \phi(t) \quad (9)$$

where,

$$V_t = |y_c^2(t) + y_s^2(t)|^{1/2}$$

$$\phi(t) = \tan^{-1}\left\{ y_s(t)/y_c(t) \right\} \quad (10)$$

The received envelope and phase have probability density function given by

$$p(V_t) = \frac{V_t}{2\pi \sigma_y^2} \exp\left| -\frac{1}{2\sigma_y^2} (V_t^2 + A^2) \right| I_o\left(\frac{AV_t}{\sigma_y^2}\right)$$

$$p(\phi/\theta) = \frac{1}{2\pi} \exp\left| -\frac{A^2}{2\sigma_y^2} \right|$$

$$+ \frac{A \cos(\phi-\theta)}{2\sqrt{2\pi}\, \sigma_y^2} \exp\left| -\frac{A^2 \sin^2(\phi-\theta)}{2\sigma_y^2} \right|$$

$$\cdot \left| 1 + \mathrm{erf} \left\{ \frac{A \cos(\phi-\theta)}{\sqrt{2}\, \sigma_y} \right\} \right| \quad (11)$$

The fading coefficient d with respect to white noise power present in the signal is defined as the ratio of power in the fading component of the signal to the white noise power and is given as

$$d = \frac{\sigma_2^2}{\sigma_1^2}$$

$$\text{or } r = \frac{A^2}{2\sigma_1^2}$$

The probability of error in terms of signal-to-noise ratio and fading coefficient is given by

$$P_e = \frac{1}{2} \left| 1 - \mathrm{erf} \left(\frac{r}{1+d}\right)^{1/2} \right| \quad (12)$$

Eqn.(12) gives the required relation between the probability of error, fading coefficient and signal-to-noise ratio.

4. CONCLUSION

Probability of error is decreasing function of Signal-to-noise ratio, for a given value of fading coefficient, but is an increasing function of the fading coefficient for a given signal-to-noise ratio.

The received signal-to-noise ratio is a function of fading coefficient and hence the function of variance of fading component and the bandwidth of the receiver. Since the variance of the fading component due to natural phenomenon of fading is beyond control, the only parameter that can be controlled to minimize the fading coefficient is the bandwidth of the receiver filter and hence the data bandwidth. Thus the fading coefficient can be decreased by increasing the bandwidth and hence the probability of error seem to be minimized. But at the same time the effect of additive noise increases with the bandwidth. This implies that there should be an optimum setting of the receiver bandwidth to minimize the total effect of additive noise and fading on the receiver.

For low values of fading coefficient the required signal-to-noise ratio for achieving a given probability of error is very low even though it increases with increasing values of fading coefficient and finally establishes a linear relation between two parameters. It implies that at high bandwidth, the required signal-to-noise ratio is very less compared to low bandwidth, even though the requirement increases in a faster rate for the changes in bandwidth.

If the receiver is designed to operate at an error probability of 0.0062 then to get an error probability of 0.0007 the required increment in signal-to-noise ratio is 2 dB, whereas to change the error probability from 0.0007 to 0.00007 the required increment in signal-to-noise ratio is 1.5 dB.

If the fading depth is very high then the increase in signal power at the transmitter will not increase the detection efficiency. This gets a limit on signal-to-noise to achieve the optimum performance.

Quality and Reliability of a Satellite-Linked Biomedical Communications Network

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Abstract

Presented here is an evaluation of channel quality and system reliability demonstrated by a network of small earth terminals linked via the Communications Technology Satellite. The channel quality evaluation focusses on the link margin statistics, as well as the quality of the video and audio signals received. System reliability is evaluated in terms of the overall network availability, and the causes of outages experienced are identified.

1. INTRODUCTION

Over the last two decades satellite communication systems have gained widespread acceptance in long distance telephony, intercontinental video transmissions, maritime and aeronautical communications, high-speed data transfer, in addition to several other applications. Until recently, most commercial broadband applications have relied on large parabolic ground antennas, operating at frequencies largely in the 4 to 6 GHz C- band. It has long been recognized that to develop the significant role that satellites could play in expanding broadband telecommunications for a new class of user, such as a health agency or an individual educational institution, it would be necessary to substantially decrease the size and cost of the ground equipment, in addition to opening up the less crowded higher frequency regions in the electromagnetic spectrum. The Communications Technology Satellite (CTS), an experimental spacecraft launched in 1976 as a joint U.S.-Canadian venture, was an important element in these necessary developments since it operated in the K-band, 12 to 14 GHz region, and was equipped with a specially developed high powered and highly efficient 200 watt transmitter. It might be noted that several communication satellite systems planned for the 1980's will operate at K-band, such as the Canadian Anik-C and the Satellite Business Systems spacecraft.

CTS provided users such as health agencies, private companies and universities, the opportunity to explore their potential needs for, and use of, satellite communications (1). Experiments were carried out in video teleconferencing, continuing education for health professionals, dissemination of research results, and other areas. In addition, CTS allowed an evaluation of the technical performance of broadband networks in terms of quality, reliability, maintainability, and operating procedures. This paper documents the investigation of channel quality and system reliability of a Public Health Service (PHS)-sponsored network of six small earth terminals linked via CTS. The six sites were Bethesda, Maryland; Seattle, Washington; Bozeman, Montana; Lexington, Kentucky; Denver, Colorado; and Fairbanks, Alaska.

Among the questions concerning communications conducted via a satellite such as CTS, some of the most pertinent relate to the ground facilities employed, such as the following:

- Since adverse weather conditions are known to cause attenuation and degradation of K-band signals by absorption, scattering and depolarization, were the 12 to 14 GHz transmissions in the network of high quality and reliability?
- Since the costs of such a system partly depend on the degree of restrictiveness of the design specifications, can these specifications be relaxed with little sacrifice in quality, reliability, and technical capability? For instance, if it should be found that the link margins are consistently larger than assumed during the design phase, the specification on system temperature or antenna gain in a similar system might be relaxed, with a corresponding saving in cost.
- What were the causes of problems or shortcomings observed in the operation of the network?

This paper attempts to provide answers to these questions.

2. DESIGN CONSIDERATIONS

CTS provided geographical coverage in both the United States and Canada by virtue of its position at 116° West Longitude in synchronous (geostationary) orbit, and by the fact that its two steerable antennas could be positioned to locate their "footprints" anywhere in the Americas. Each footprint, nominally corresponding to a 2.5 degree 3 dB beamwidth, was large enough to cover an area approximately equal to the entire West Coast as shown in Figure 1.

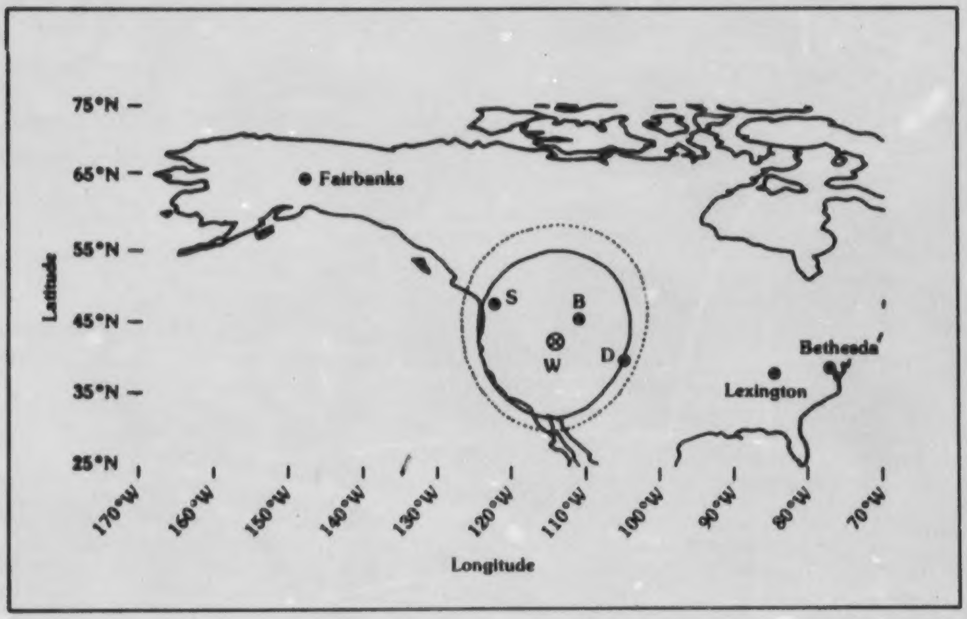
75°N
65°N
55°N
45°N
35°N
25°N
Latitude
Fairbanks
S
B
W
D
Bethesda
Lexington
170°W
160°W
150°W
140°W
130°W
120°W
110°W
100°W
90°W
80°W
70°W
Longitude

Figure 1 3 dB Coverage Including Seattle, Bozeman, and Denver, with Boresight Pointed toward Wendover, Utah.

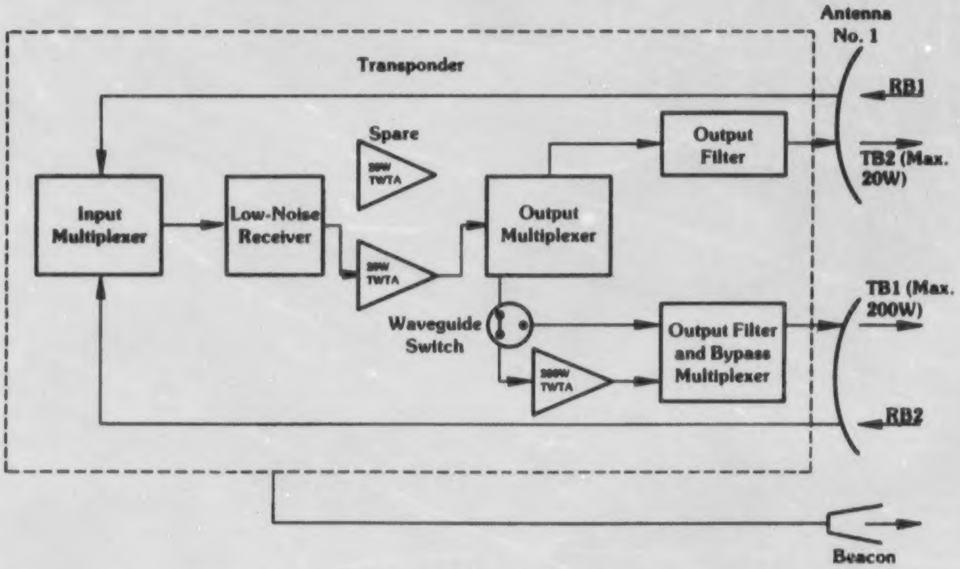
Antenna
No. 1
Transponder
RB1
Spare
20W
TWTA
Output
Filter
TB2 (Max.
20W)
Input
Multiplexer
Low-Noise
Receiver
20W
TWTA
Output
Multiplexer
TB1 (Max.
200W)
Waveguide
Switch
Output Filter
and Bypass
Multiplexer
200W
TWTA
RB2
Beacon

Figure 2 CTS Communication Subsystem (Simplified Block Diagram)

A key feature of CTS, simultaneous two way video and audio communications (full-duplex), was made possible by the transponder configuration shown in Figure 2, consisting of a high powered 200 watt traveling wave tube amplifier (TWTA), redundant 20 watt TWTAs, and a sensitive high-gain receiver. It had two 85 MHz passband channels: two receive bands (RB1 and RB2) in the 14.0 to 14.3 GHz range, interfaced with transmit bands (TB1 and TB2) in the 11.7 to 12.2 GHz range. TB1 and TB2 were capable of transmitting down 200 and 20 watts of power respectively. As an aid to ground antenna tracking, the satellite also transmitted a 200 mW beacon signal at 11.7 GHz.

To describe full-duplex operation briefly, the transponder received 14 GHz signals in the RB1 band via antenna No. 1, amplified and frequency translated them down to 12 GHz, and retransmitted the signals through antenna No. 2, in the TB1 band. Meanwhile, the transponder could simultaneously receive other 14 GHz signals (RB2) via antenna No. 2, also amplify and frequency translate them to 12 GHz, then re-radiate them through antenna No. 1 in the TB2 band.

The "signals" referred to are two carriers, each modulated by a color video baseband signal and four associated audio subcarriers at frequencies ranging from 5.14 to 6.3 MHz. In addition, each earth terminal in the network had the capability of transmitting a separate audio-modulated "orderwire" carrier occupying either 85 MHz band simultaneously with the main carrier in that band. This orderwire was instrumental in increasing the flexibility of operation, by providing a third party the ability to interrupt an ongoing video interchange between two other sites, without disrupting that interchange.

To take maximum advantage of the satellite's capabilities, a network of earth terminals was designed with complementary parameters. These design parameters included the ground transmitted power, system noise bandwidth, antenna gain and receiver noise temperature. Of these parameters, a 10 foot diameter antenna was first selected, because it was judged that any increase in gain available by specifying a larger antenna would be offset by the operational difficulties caused by the increase in size, weight and the more rigorous tracking requirements of the larger antenna.

During the design phase, the selection of antenna size was followed by an analysis which predicted system performance under various transmitter-receiver combinations. This analysis, documented in (2), showed that an assumed FM threshold of 11 dB would be exceeded in both channels by using a low noise receiver with a noise temperature less than 220° K, and a high power amplifier (HPA) with transmit power of 588 W. With these ground station parameters, it was determined that the network would theoretically limit rain-caused outage to a range of 0.1 to 1.0%, corresponding to 9 to 90 hours per year. To summarize, the key elements of the earth terminals actually employed were: a 10 foot antenna, a low-noise parametric amplifier with a noise temperature of 160° K, and a klystron HPA with an output power rating of 2 kW.

3. EXPERIMENTAL RESULTS AND DISCUSSION

Observations made during the conduct of the technical evaluation of the network, and the conclusions reached, are summarized below, and documented in detail elsewhere (3).

3.1 CHANNEL QUALITY

The evaluation of channel quality, including both link performance as well as signal baseband performance, is summarized in this section. Observations related to link performance appear below:

- The link margins available at all six stations averaged 7 dB in Band 1, and 6 dB in Band 2. The primary reason that Band 1 did not deliver the higher link margins expected from the 200 W TWTA was that the downlink power in this TWTA was restricted for safety reasons;

- A trend analysis (selected examples appearing in Figs. 3 and 4) of link margin at each of the six sites revealed no detectable variation over the year, confirming that over the approximately one year period of such data collection, earth terminal and satellite capability did not markedly change;

- Performance statistics (as in Figs. 5 and 6) derived from cumulative probability distributions of C/N indicated that the FM threshold of 9 dB was exceeded 98% of the time;

- The attenuation effects of precipitation and overcast conditions on the K-band links were observed to average 1 to 2 dB at Bozeman and Fairbanks (Figure 7). No statistically significant effects were observed at the other sites. In general, the effects of weather were not serious factors in the network's performance, except on one occasion in 1978, when a complete outage occurred during exceptionally heavy rain and hurricane-like conditions;

- For the full-duplex mode of operation, the average uplink power was 117 W in Band 1 and 268 W in Band 2. For the simplex (or one-way broadcast) mode, the average uplink power was no more than 62 W in Band 1. Band 2 was rarely used for simplex operation. This leads to the conclusion that instead of using the 2 kW klystron transmitter installed in the network for experimental purposes, an operational system could use a more economical 200 W traveling wave tube transmitter, or at most a 500 W klystron, to

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FIGURE 3

CARRIER TO NOISE RATIO IN BAND 1
Full Duplex Operation, Seattle
Mean = 15.6 dB, Sigma = 1.81 dB

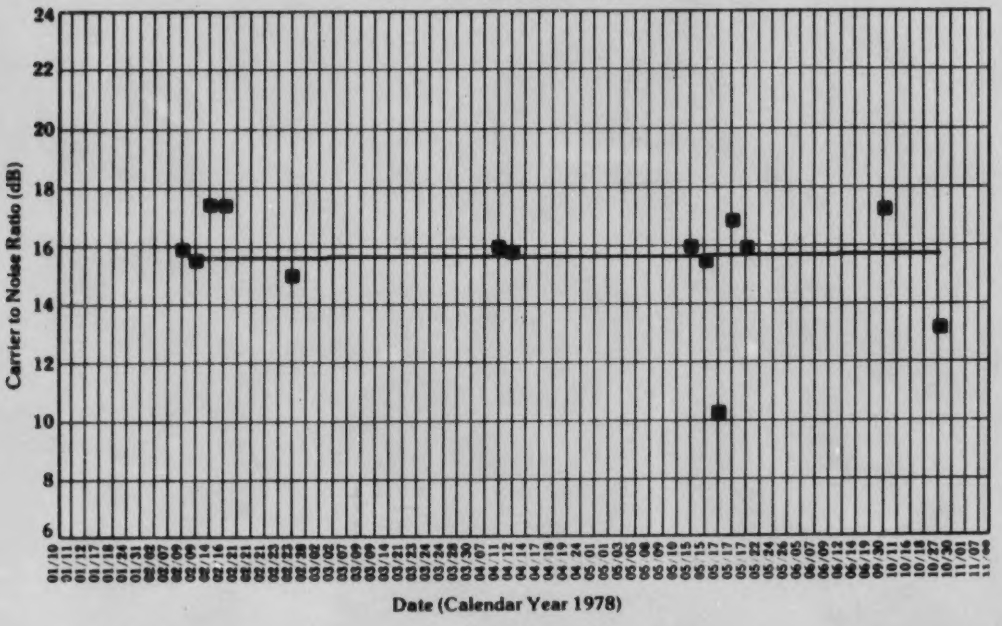


FIGURE 4

CARRIER TO NOISE RATIO
Full Duplex Operation, Seattle, Band 2
Mean = 16.4 dB, Sigma = 2.05 dB

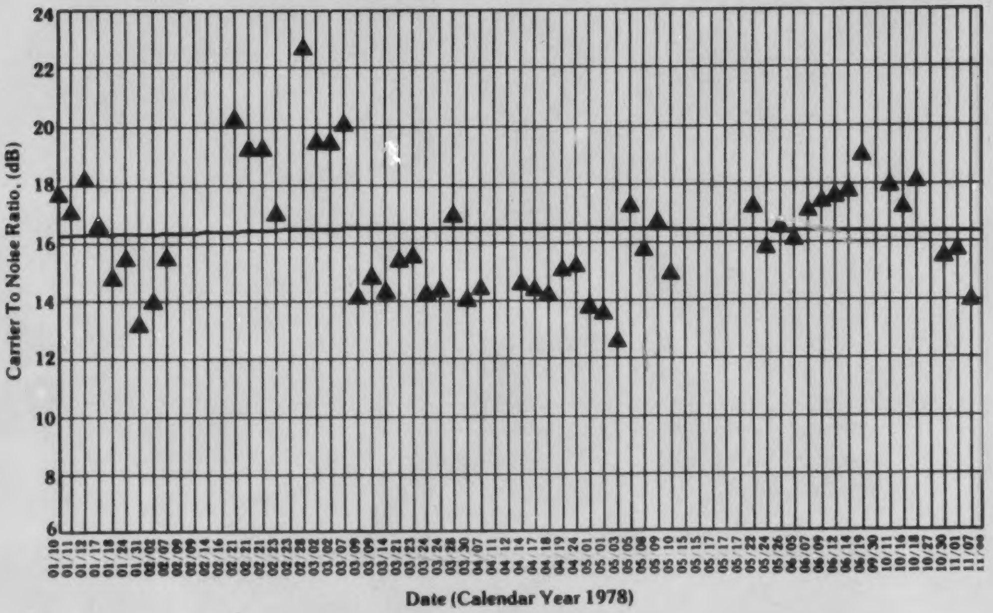


FIGURE 5

PERFORMANCE
Bethesda, Bands 1 & 2

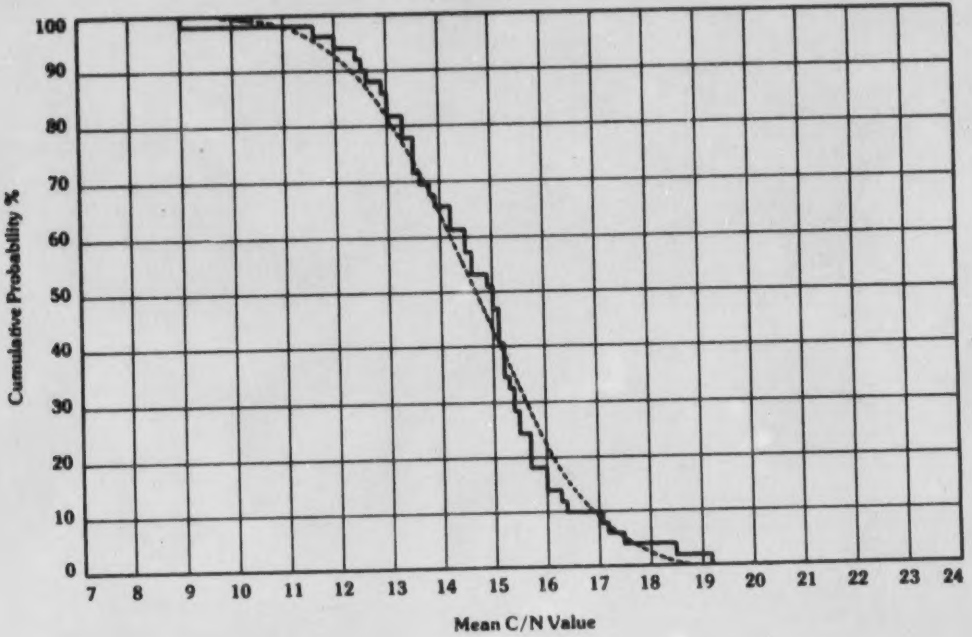


FIGURE 6

PERFORMANCE
Seattle, Bands 1 & 2

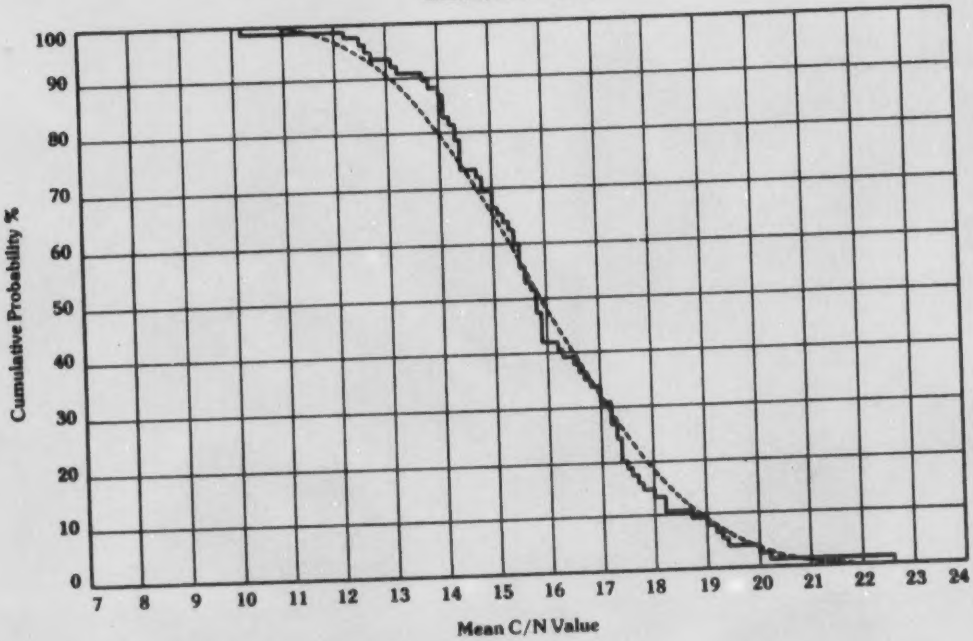
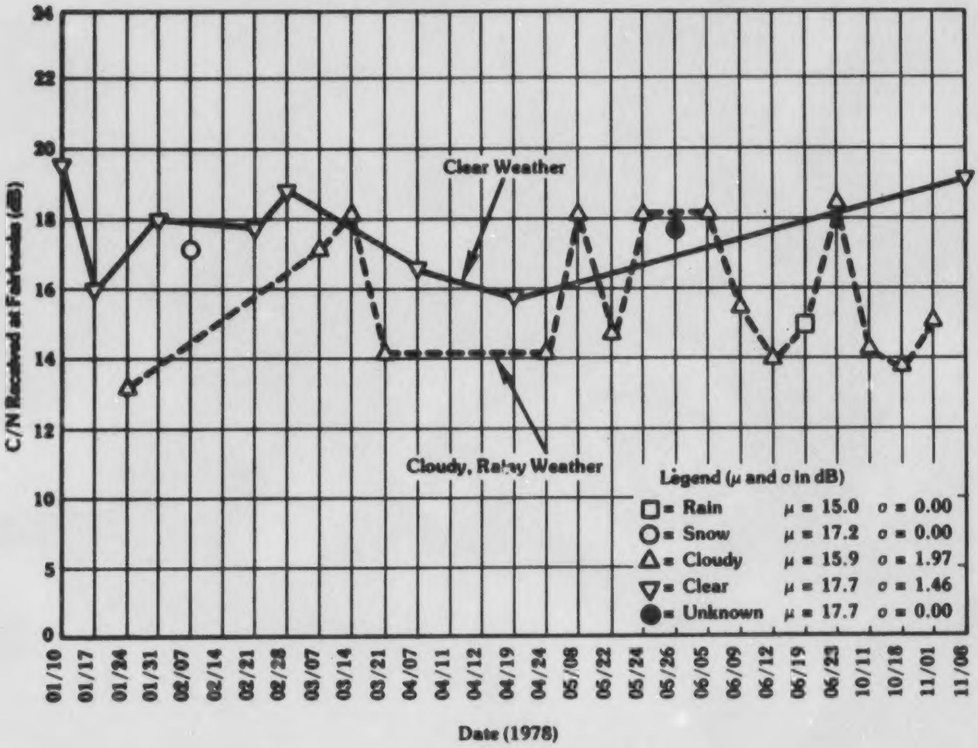


FIGURE 7

WEATHER EFFECT ON C/N, FULL DUPLEX OPERATION, LOCATION FAIRBANKS, BAND 1



achieve a comparable level of performance;

- In view of the typical link margins obtained, it was concluded that a higher noise GaAsFET amplifier could be substituted for each parametric amplifier, at one-tenth the cost, with a loss of no more than 1.5 dB in link margin. This low-cost device was actually used as a substitute during maintenance problems experienced with the low noise receiver;

- o While the availability of automated satellite tracking was a convenience, it was not found to be an absolute necessity. With the tracking capability unused, it was found that the link margins showed decreases of 0.5 to 3.0 dB over a one-and-a-half hour period depending on the satellite's position at those times. For future geostationary satellites with tighter tolerance on station-keeping, it may reasonably be assumed that occasional manual peaking would suffice, thereby eliminating the need for costly automated tracking. On the other hand, while automated tracking may not be a necessity, the convenience of motorized controls (to permit the operator inside the building to vary the antenna's azimuth and elevation angles) and a beacon receiver (to enable CTS to be acquired without requiring another ground terminal to transmit a signal to lock onto) were found to be extremely useful. The lack of such controls at some non-PHS stations was found to cause delays of up to 40 minutes in starting the programs.

An evaluation of the quality of video and audio baseband signals led to the following observations:

- o The video signal quality consistently met the design goal of TASO Grade 1, or "excellent" level. The measured peak-to-peak video signal-to-weighted rms noise, S/N, averaged 51 to 54 dB, for peak deviations of 10 and 13 MHz respectively. The latter value for peak deviation, used routinely by the PHS terminals, could not be employed when certain non-PHS stations were involved, resulting in a 3 dB loss in signal quality. Many of these stations lacked the capability to deviate by 13 MHz, whereas all PHS stations were designed to select any value between 5 MHz and 15 MHz;

- o Besides S/N, the other major indicator of video signal quality, particularly as regards color performance, is a set of distortion measures, standards for which have been set by the Network Transmission Committee (NTC). Color quality was consistently high, demonstrated by the fact that of the twenty linear and nonlinear distortion measures, only one fell slightly short of the NTC level, while the others performed well within the limits.

- o The quality of the audio signals in terms of signal-to-noise ratio met the designed level of 47 dB. However, the first audio channel at a subcarrier frequency of 5.14 MHz (the one closest in frequency to the video baseband) was found to exhibit more noise than the other three, especially when the video baseband was occupied by a signal from an electronic character generator. This quality difference encouraged the use of the two channels farthest removed from the video to be used most often for program audio, and the closest one for a voice link between the earth station operators;

- o The major audio deficiency that detracted from allowing geographically-separated participants from interacting in a "natural" manner was the echo phenomenon. The approaches initially attempted, such as manual echo control and the use of comercially available echo suppressors, were unsatisfactory. A detailed investigation of the problem was undertaken (4), yielding a satisfactory and cost-effective solution for echo control: a tandem combination of a voice gate amplifier, also commercially available, and the echo suppressor. Incorporating this solution, it was found that for unidirectional speech, the echo level was 50 dB below normal audio and was completely inaudible. During double talk (simultaneous two-way speech), echo was found to be between 30 and 40 dB below the normal audio level, depending on the speaker-to-microphone isolation at the studio generating the echo. Despite these higher levels, it was noted that the echo during double talk was not disruptive, because of the masking effects of the desired speech.

3.2 SYSTEM RELIABILITY

System reliability, in the sense of network outage level and equipment maintainability, was evaluated, leading to the following observations and conclusions:

- o Out of 565 scheduled program hours in the period between January and November 1978 selected for analysis, about ten hours of outage were recorded, representing a network outage level of under 2%;

- o The dominant cause of outage in 1977 was satellite-related: specifically, the unavailability of spacecraft telemetry causing the cancellation of at least six programs and early termination of five others. This telemetry, indicating satellite output power, allowed network control to monitor and limit uplink power to safe levels for the satellite TWTAs. Its absence meant that some stations might beam up at power levels high enough to damage the TWTAs, unbeknownst to network control. By 1978, however, safe limits on ground transmitted power were imposed on all earth stations in lieu of telemetry control;

- The dominant cause of outage in 1978 was related to earth terminal or studio equipment. Of the 21 recorded instances, 7 were due to malfunctions at the PHS stations;

- The overall experience with the PHS earth terminal equipment indicated that it was a reliable system, with the exception of two items, the klystron and the phase-lock loop oscillator. It should be noted that the relatively low reliability experienced with these devices could cause higher levels of outages in a constantly used operational system. However, in this experimental program, since not all six sites were operated simultaneously, it was possible to avoid outages by replacing a malfunctioning device at one site by its counterpart at another. The following outlines the experience with these two devices:

  (a) The 2 kW klystrons failed nine times throughout the network in the 16-month period between August 1977 and December 1978. Almost all failures were due to the leakage of gas into the tube, causing destruction of the cathode and sometimes damaging the collector. The time taken by the manufacturer to repair the damage was considered excessive, at times as long as six months. The reason given for the delay was the difficulty in obtaining components for the tube from the various suppliers;

  (b) At each site, the phase-lock loop oscillator was a component of both K-band upconverter and downconverter, as well as the beacon receiver. The device failed on a number of occasions. However, the exact cause of failure was not locally determined since all units were sealed and needed to be repaired at the vendor's factory. The turnround time for repair in this case was also excessive, taking up to three months.

4. CONCLUSION

This paper has summarized the evaluation of channel quality and system reliability of a network of small earth terminals linked via the Communications Technology Satellite. It was found that the K-band transmissions were of high quality and reliability even in the presence of adverse weather conditions. It was also found that the specifications on the high power amplifier and the low noise receiver, and the requirement for automated tracking, were more restrictive than necessary. The substitutions that make cost savings possible are mentioned.

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Determination of Microwave Interference Levels - A Computerized Approach

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Abstract

This paper provides an overview of the design of composition of the Canadian Telecommunications Carriers computerized Microwave Interference Calculation System (MICS). It briefly describes the reasons for establishing MICS and explains its features some of which are believed to represent a novel approach to microwave coordination.

1.0 INTRODUCTION

1.1 Scope

The subject matter will be covered as follows:

- Introduction
- Description of Microwave Interference Calculation System (MICS)
- Administration
- Conclusion
- Acknowledgements

1.2 Canada and Telecommunications

Canada is composed of ten provinces plus the Yukon and North West Territories. It is bounded by three oceans: the Atlantic to the east the Pacific to the west and the Artic to the north. The southern border is some 6400 kilometers in length and is shared with the United States of America. The population is about 23 million and is mostly concentrated in a long narrow belt across the country in close proximity to the USA.

Telecommunications developments began in 1846 with the introduction of the electric telegraph. Voice telecommunications followed rapidly through the invention (1) of the telephone in Canada, in 1874 by Alexander Graham Bell. Today, telecommunications service is provided through a mixture of private and government ownership, a blend of monopoly and competition, and a combination of strict regulation and self regulation. This diversity of ownership and regulation distinguishes Canada from countries where telecommunications services are provided by the national government. This diversity also provides a microcosm of telecommunication environment to be found among neighbouring countries in many parts of the world.

Four organizations supply the majority of telecommunications services whose communications networks are continually modernized to provide a transmission quality and service that has few equals (2).

- Canadian National Canadian Pacific Telecommunications (CNCP) (3)
- TransCanada Telephone System (TCTS) (4)
  TCTS provides a full range of telecommunications services except public telegraph services.
- Telesat Canada
  member of TransCanada Telephone System, provides domestic satellite telecommunications.
- Teleglobe Canada
  provides international telecommunications services for Canada.

In addition, there are a number of smaller organizations (5) providing public telephone service throughout the country, all of which interconnect with the TransCanada Telephone System (6).

In 1972, the telecommunications organizations established the Canadian Telecommunications Carriers Association (CTCA), to act as a forum for the international resolution of industry policies and technical issues of national and international significance. CTCA (7), is also spokesman for the industry to governments, national and international organizations, the general public and the news media.

1.3 Spectrum Management

As a condition of licensing. Users of the radio spectrum in Canada are required to frequency coordinate their microwave systems with other users. Microwave Interference Calculation System was created as a tool for the system designer to perform this function.

Overall responsibilities for total frequency coordination and spectrum management rests with the Department of Communications of the Canadian Government.

1.4 History of Microwave Network Growth

A number of shorter microwave systems were established throughout Canada in the late forties and early fifties serving the local needs of the individual telecommunications companies. In 1958, the first microwave network linking together all major cities of Canada was completed by the TransCanada Telephone System. Along with message and data traffic the system carriers network television services.

In 1964 CNCP Telecommunications completed their coast-to-coast microwave system and in 1969 the TransCanada Telephone System turned up their second microwave route to provide diversity routing and increased reliability in communications to all areas served.

Due to the existing geographical barriers (i.e. the Rocky Mountains, large bodies of water, extensive uninhabited areas) and the population distribution in Canada, the three major microwave routes are constructed in a narrow belt at the extreme southern part of the country in an east west direction.

Additionally, in each province the telecommunications carriers own a considerable number of north-south microwave routes. Most of these routes interconnect with the east-west systems at major centres forming an extensive network of communication systems. The Canadian network is interconnected at several points with the communication networks of the United States. In the USA, adjacent to Canada, a large network of east-west and north-south microwave routes exist and many of these are within coordination distance of Canadian microwave systems.

In Canada, additional to the systems owned by the telecommunication carriers, there are privately owned systems operated by power utilities. ATV operators and other companies with interest in telecommunications.

In the past, several telecommunication carriers operated computerized microwave coordination systems of differing complexity. However these systems lacked uniform standards and did not have a comprehensive data-base containing up-to-date information on microwave stations located in the United States. A substantial duplication of effort was necessary among the companies with respect to data-base upkeep and interference calculations.

The factors outlined above prompted the Canadian Telecommunications Carriers Association to develop a microwave interference calculation system having the following characteristics:

- Accessible to all users working on a remote computer terminal in a conversational mode.
- Produce large outputs on a high speed printer.
- Provide dependable, accurate results assisted by a comprehensive database and microwave station data.
- Disseminate interference calculation results to all interested users upon request.

The system has been operational for over two years, having met all design requirements.

2.0 DESCRIPTION OF THE MICROWAVE INTERFERENCE CALCULATION SYSTEM (MICS)

The system has two main functions: calculation of interference between microwave stations, and cataloging the network of stations in the database.

The stations may be terrestrial or earth stations of earth-satellite links. The interference calculations are required in the process of planning new stations and protecting existing ones.

The system has two major components:

- **Master Data Base (MDB)**
- **Interference Calculation Sub-system**

2.1 The Master Data Base

The MDB sub-system consists of three parts:

- Master Data Base and subsidiary data files
- MDB updating facility
- MDB reporting facility

2.2 Master Data Base and Subsidiary Data Files:

The MDB contains technical information about every microwave station and/or earth station operated in the country and in the adjacent countries within coordination distance from the borders. The coordination distance is typically 200 km for terrestrial systems or about 500 km for satellite earth stations. Typical information on the stations includes: call sign, geographical coordinates, site elevation above sea level, tower elevation, antenna type and use (i.e. transmitting and/or receiving) equipment type, transmitter power, frequencies transmitted and received, channel capacity, adjacent station call sign etc. For an earth station, in addition to the above, the rain and climatic zones are specified and included along with satellite designation and position (longitude), interference susceptability characteristics, service-arc centre in longitude and coordination distance etc.

Antenna azimuth and elevation, distance between sites and received signal levels are calculated and stored automatically at the time of data input.

The Master Data Base currently contains about 15,000 stations. These stations are located in Canada and within coordination distances from the Canadian border in the United States. They include terrestrial stations and earth stations.

Data is stored on a station basis with radio links pointing to other stations, or to satellites in the case of earth stations. The stations are identified by their call signs. The terrestrial stations are subdivided by Province or State and are stored in separate files in order of ascending latitudes and longitudes i.e. in the order from east to west and south to north. Earth stations are stored in a separate file. This data base forms the communication environment against which all new stations are tested.

Also included in the Master Data Base are nine subsidiary data files, containing descriptive information and numeric data used in interference calculations. The files contain:

- Antenna information and discrimination tables. This file contains information on about 700 antennas. The horizontal, vertical and cross polarization patterns are coded into a minimum of 70 points, covering 360 degrees. The method of coding allows the recording of non symmetrical and polarization-sensitive patterns. New antenna patterns are easily added.
- Frequency bands and adjacency information.
- Frequency plans in common use. They are employed in "Plan" analysis options of interference calculations.
- Interference objective tables: developed considering spectral characteristics of wanted and unwanted signals. Their development is detailed under 2.8.
- Equipment characteristics. Frequency Stability characteristics are stored in this file.
- Route information
- Tower types and description
- Information on operating companies related to radio systems coordination - contact personnel names for each Company.
- Note file.

2.3 Data Base Updating Facility

The data base is updated by transferring a specific user file into the data base. Each user organization is responsible for keeping its data current and accurate.

Only CTCA HQ is authorized to update the master data base. This is a safeguard to protect the data base integrity. Updates are initiated upon successful frequency coordination of a new system, or upon receipt of updated information of an existing system.

Each update is automatically listed in the Notice File which is printed out whenever a user signs on. As a further safeguard, copies of the Notice File are mailed out weekly to all users. These procedures ensure that the users of MICS are aware of all changes that could affect the operation of their microwave system and in case of a possible conflict, could take appropriate action.

2.4 The Data Base Reporting Facility

This facility produces printouts on demand, of specific parts or all of the data base. It is used, among other things, to produce a Radio Catalog of all stations in the database.

The printouts can be keyed on virtually any parameter that is contained in the MDB. In addition, information can be listed based on a latitude-longitude "box", operator code, region code, route number, call sign, equipment type etc. A number of limiting parameters may be included; for example: a specific equipment type operating on a specified frequency may be requested for a certain operator.

The output may be presented in a report format or in the format of an operating file. This feature eliminates the need to input a station in a working file manually, once it is contained in the database. Modification to data in the data-base is possible without duplication thereby minimizing the chances for human error.

2.5 Interference Calculation Subsystem

The interference calculation subsystem of MICS is capable of calculating interference between:

- Terrestrial stations and other terrestrial stations
- Terrestrial stations and earth stations
- Terrestrial beam and satellite orbit intersection points

To perform interference calculations a file of stations to be analysed is constructed by the user. After validity checking of the data, using part of the MDB updating facility, a new file is generated by the system that includes relevant and associated data from the master data base to be processed by the interference calculation programs.

2.6 Terrestrial-to-Terrestrial system Calculations

A series of tests are made on all stations in the user file against files in the MDB that are specified in the appropriate region adjacency index.

The following test criteria is used to eliminate stations as a possible source of interference:

- Greater than 200 km distance apart
- If no frequency band of the stations is common or adjacent
- On the basis of company code if "PROTECT" mode is selected.

("PROTECT" mode procedure applies where a MICS user wishes to ascertain whether a new or changed microwave installation belonging to another company will cause harmful interference into his existing or proposed stations).

The above eliminations use algorithms that calculate the distance between stations based on geographical coordinates.

Pairs of stations that are not eliminated in the manner described above are subjected to interference analysis.

Four types of analysis are available. These are:

- Band analysis
- Plan analysis
- Channel analysis
- Plan-Channel analysis

and their description follows:

Band Analysis excludes all station pairs having a Carrier to Interference ratio (C/I) exceeding 110 dB, based on free space loss, antenna discrimination, feeder loss, maximum transmitter power and minimum received signal. The analysis may stop at this point at user request. Otherwise, failing cases are passed on to the next step i.e. plan vs plan analysis.

Plan Analysis option coordinates microwave systems for ultimate expansion using all frequencies in a frequency plan, with specified polarizations.

For this analysis the frequency plan file is accessed. This file contains either existing or future frequency plans, but if a plan is missing the analysis proceeds on a channel analysis basis (described below). In plan analysis the frequency separations are found and used to determine the acceptable C/I levels using Interference Objective tables stored in the MDB. This value is then compared with the calculated C/I level and failing cases are reported.

Channel Analysis tests the channels actually in service against the proposed system. Actual transmitter powers and received signal levels are used in the calculation of C/I ratios which are then compared to the Interference Objective Curves and failing cases are reported.

This analysis is used to determine if a proposed channel addition is feasible in a congested environment, without necessarily considering future expansion capability.

Plan Channel Analysis coordinates a specific channel - determining future expansion capability - in an existing system, using actual transmitter powers and received signals, not maximum or minimum values. The frequency separation is found between the plan at one station and a group of channels at the other. The procedure from this point is similar to plan vs plan analysis.

2.7 Earth Station to Terrestrial System Calculations

The following test criteria is used to eliminate stations as a possible source of interference:

- Separation distance greater than maximum coordination distance, stored with earth station data.
- If no frequency band in the stations is common or adjacent.
- On the basis of company code in "PROTECT" mode as explained under terrestrial systems (2.6).

Pairs of stations that are not eliminated in the manner described above are then subjected to a non frequency sensitive analysis of each station in the user file against each station in the data-base file. Stations may be eliminated as non-interfering if the interference (I) values are lower than predetermined values.

There are two significantly different mechanisms by which an interfering emission may be propagated between an earth station and a terrestrial station. The first is the propagation of radio waves through the troposphere along paths essentially in the great circle plane between the transmitting and receiving stations. The second is the propagation of radio waves due to scattering from volumes in the troposphere which may be, but are usually not, in the great circle plane.

In the great circle propagation mode basic transmission loss between two stations is estimated on a worst case basis for a large and a small percentage of time, i.e. 20 and 0.01 percent respectively. The model assumes line of sight propagation paths for separation distances less than 90 km. For distances greater than this, the propagation modes considered are tropospheric scatter and ducting.

Precipitation scatter mode: radio beams emanating from transmitting antennae do not, of course, stop at the intended receiver. As the beams continue past the receiving antennae they spread out in both the horizontal and vertical directions. In about 300-500 km they reach the average height that rain cells commonly occupy.

If beams intersect, precipitation scatter propagation is evaluated for the scatter volume formed for 0.01 percent of the time.

For non intersecting beams, the transmission loss for main lobe-side lobe case is estimated for up to four rain cell locations in each beam, if all or any part of the beam is above the radio horizon of the other station. These four locations are:

- minimum scatter height
- minimum distance
- minimum discrimination
- maximum scatter height

Refraction correction is applied to the radio beam in the determination of antenna discrimination angles.

These calculations can be performed for earth stations operating with a single satellite, or if the user desires, they may be done for satellites within a specified orbital arc. This is necessary to preclude re-coordination of the earth station if an operational satellite has to be relocated at some future time.

Calculations using plan versus plan and plan versus channel modes are similar to the terrestrial system case.

2.8 Carrier to Interference Objective Curves

Carrier to interference objective curves are stored in the MDB for commonly occuring system capacities and traffic types. These curves were derived based on spectral characteristics of frequency modulated analog signals. Formulae have been published in the literature describing the spectrum of signals having a range of modulation indices (m). Three ranges were used in this system.

The formula described in (8) for m smaller than 0.1; (9) for m having the value between 0.2 and 1.5 describing experimentally determined results, and (9) for m greater than 1.5 were employed to determine the signal spectrum.

Having determined the spectrum of the desired and interfering signals they are combined by the mathematical process of convolution to yield the baseband interference spectrum (10). From this information, using interference noise objectives, the carrier to interference objective curves were determined.

New radio systems employing signals whose spectral distribution is different from FM signals will be accomodated easily by the development of the appropriate set of carrier-to-interference objective curves. Digital radio coordination, for example, will be handled in this manner. This method allows flexibility in accomodating any conceivable modulation scheme that is likely to be used in the future.

The shape of these curves indicates that as the frequency separation between the interfering carrier and the desired signal varies from zero to twice the IF frequency the necessary C/I ratio first increases then decreases. In using these curves, the frequency stability of the desired and interfering signals are considered, and the worst case C/I ratio is used in the calculations that result from the applicable range of frequency separation between carriers.

2.9 Equipment Response Curves

Equipment response curves representing input filter characteristics are combined with the interference objective curves described above for commonly used equipment, to minimize computation time.

2.10 Terrestrial System Beam Geostationary Satellite Orbit Intersection

The third mode of analysis is the terrestrial system beam geostationary satellite orbit intersection calculation. These calculations are performed on new stations to avoid interference with existing or future satellite systems placed in an equatorial orbit, in keeping with CCIR Recommendation - 406-3 and 406-4.

The calculation programs use approximation functions which provide an efficient and accurate means to determine orbit intersections by terrestrial station beams.

2.11 Auxiliary Calculation Programs

There are a number of auxiliary programs available to help the designer in post analysis. The more important ones calculate the following:

- Passive reflector radiation patterns
- Free space path loss
- Obstruction path loss
- Signal powers in a hop using passive reflectors

3.0 ADMINISTRATION

3.1 Operation

System operation as seen by the user was kept as simple as possible. The system was designed for use of personnel with very little technical training (clerical employees) to input and update information stored in the MDB.

Technical expertise is required only in the process of validation of input information on new and planned microwave systems and during interpretation of interference calculation results. These functions are normally performed by highly skilled personnel.

In each user company a small group of people are trained to operate the system and perform radio system coordination as required. The size of this group of course varies with the size of the company. At CTCA HQ two people are trained to operate MICS on a day to day basis. Overall system administration and management is being provided by CTCA HQ.

3.2 Operational Experience and Maintenance

MICS has been operational since April 1978. Since that time a number of small software bugs were found and eliminated. Due to the extensive testing program undertaken before the software was placed in service, no major problems were encountered to date that affected the service provided by MICS or had an effect on calculation accuracy. A careful log is kept on all the bugs reported and the steps taken for their repair.

Software maintenance is being provided through contract with Orthogonal Endeavours Ltd. - a software house based in Vancouver, British Columbia.

A committee of experts from the Telecommunication Carriers is responsible for the provision of technical information and the solution of technical problems related to MICS. This committee is also responsible for long term planning of system operation and future expansion.

3.3 Training

A comprehensive, detailed manual was developed for MICS to cover operational details. It has been a major factor in keeping operational difficulties at a minimum level.

An eight day training course covers the following topics:

- General computer system access, input, output, use of system editor, etc. two days.
- Preparation of files system updates information retrieval workshop, two days.
- Interference calculation routines including practical workshop - four days.

The level of training was found sufficient to assure practically trouble free operation by the member companies. Minor user problems are usually resolved immediately upon receipt at CTCA HQ.

3.4 Adaptability

The Microwave Interference Calculation System was implemented on Computer Sciences of Canada, Ltd. (11) facilities using a Univac 1108 computer and associated operating system. The features of the system editor offered by CSC were particularly attractive in achieving the objective of keeping system updates easy and requiring minimal technical expertise.

The implementation of MICS on another computer is possible, but could require considerable work on software.

4.0 CONCLUSION

The Microwave Interference Calculation System is in operation, to the satisfaction of the 20 member companies of CTCA.

- System objectives have been achieved.
- The system is nation-wide and available to all telecommunications carriers from coast to coast.
- Radio system designers have a tool that identifies quickly the source of radio interference and where the new system is likely to cause interference

- Calculation results are available to both the "Interferor" and the "Victim" for mutual resolution.

It is expected that the system will remain operational for many years. It will be continually updated to stay abreast with advances of telecommunication technology.

5.0 ACKNOWLEDGEMENTS

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3) CNCP provides telephone service in certain areas of Newfoundland, the Yukon, Northwest Territories and northern British Columbia.

4) The TransCanada Telephone System (TCTS) is composed of: Alberta Government Telephones, British Columbia Telephone Company, Bell Canada, Island Telephone Company Ltd.,Manitoba Telephone System, Maritime Telegraph and Telephone Company Limited, The New Brunswick Telephone Company Limited, Newfoundland Telephone Company, Québec Téléphone, Saskatchewan Telecommunications, Telesat Canada.

5) A number of these companies are members of the Canadian Telecommunications Carriers Association, as listed in reference (7), such as edmonton telephones, Northern Telephone Ltd., Ontario Northland Communications, Télébec Limitée. A number of these companies are represented by the Canadian Independent Telephone Association (CITA), also a member of the Association.

6) Five telecommunications organizations are regulated by the Canadian Government, namely British Columbia Telephone Company, Bell Canada, Canadian National Telecommunications, Canadian Pacific Telecommunications and Telesat Canada. Other telecommunications organizations are regulated by provincial or municipal governments.

7) Canadian Telecommunications Carriers Association (CTCA) is composed of 20 member organizations: eleven members of the TransCanada Telephone System, the TransCanada Telephone System itself, Canadian National Telecommunications, Canadian Pacific Telecommunications, edmonton telephones, Northern Telephone Limited, Ontario Northland Communications, Télébec Limitée, Canadian Independent Telephone Association, and Teleglobe Canada.

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11) Computer Sciences of Canada Ltd. is located in Montreal, with computer system installations at Toronto, Ontario and Calgary Alberta. CSC provides time shared computing service in all major cities in Canada.

Syncompex - A Voice Processing System for Low Cost HF Radio Telephony

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Abstract

HF radio telephone still plays an important part in providing basic communications in many regions of developing countries where conditions prohibit the deployment of other types of systems such as microwave or satellites. The quality of voice provided by HF radio telephone often falls short of the standard provided by alternative service. Syncompex is a system which can be used in conjunction with HF radio to provide improvements to voice quality and intelligibility in the presence of interference and fading. Significant improvement in system performance has been observed during operational trials.

1. Introduction

Despite recent advances in other types of communications services, high frequency (HF) radio continues to be widely used throughout the world. This popularity is no doubt due to the relatively modest investment in HF equipment needed to acquire the capability of communicating over large distances. From the user's point of view, however, HF radio telephone systems have some obvious shortcomings. The list of shortcomings includes high noise levels, interference, fading, and audio distortion.

The severe distortion caused by frequency-selective fading which plagues HF transmissions using conventional amplitude modulation has been largely eliminated in radio telephone systems by the adoption of single sideband (SSB) suppressed-carrier modulation. Automatic gain control (AGC) circuits in HF receivers can counteract the effects of flat (i.e., nonselective) fading to some extent. The fact remains, however, that HF voice circuits often tend to be unpleasantly noisy. This is particularly noticeable during the pauses or quiet intervals in speech; not only are the noise and interference no longer masked by speech, but the receiver gain control circuits tend to increase the noise level, causing a "blasting" effect.

In telephone practice, the weapon most commonly used against noisy voice circuits is the compandor. Although the application of this device is relatively straightforward when the communication channel has constant loss, it becomes considerably more difficult when a fading channel must be used. In the latter case, the expander at the receive end of the circuit is unable to restore the voice waveform properly, since it cannot distinguish between those variations which exist on the envelope of the voice signal after it leaves the compressor, and those variations which are introduced by fading on the channel. The result is that the expander will amplify the effects of the fading, which tends to negate the benefits normally derived from the introduction of the compandor.

In the mid 60's, a compandor system specifically designed for HF radio service, called Lincompex, was developed by the British Post Office (1). The most significant innovation in this development was a control channel, transmitted at the upper end of the voice band, which informed the expander of the gain variations introduced by the compressor. The expander can then perform the complementary gain changes without errors caused by fading. This system has enjoyed considerable success, but its areas of application have been severely limited by its high cost. Users of Lincompex have also encountered operational problems which stem from the manner in which the control channel was implemented. The control channel uses a subcarrier onto which the compressor gain changes are frequency modulated. In order to recover this information accurately, the intervening SSB radio equipment must have very good frequency setability and stability, such that the end-to-end frequency offset caused by the radios is no more than 2 Hz. This often means in practice that radio operators must perform a manual tuning procedure periodically or each time a new channel is selected. In addition, the narrowband nature of the control channel makes it susceptible to dropouts caused by selective fading.

Syncompex (a contraction of synchronized compressor and expander) represents a new approach in HF compandor design and is intended to alleviate some of the problems just outlined. Digital signal processing techniques are used to take advantage of the potential cost saving offered by recent advances in microprocessor/LSI technology. The control channel is also digital and is designed to tolerate much larger frequency offsets than Lincompex. This eliminates the need for manual fine tuning with typical channelized SSB radios. Vulnerability of the control channel to selective fading is reduced by the use of inband frequency diversity. The RF spectrum required is the same as for a normal SSB transmission. This allows Syncompex to be used with standard radios and also to be retrofitted to many older radios already in service.

Tests in which ionospheric fading and high ambient noise were encountered showed that a substantial improvement in signal-to-noise ratio can be attributed to the use of Lincompex (2). As expected, a similar degree of improvement has been achieved with Syncompex. Experimental results, obtained over HF paths of 60 km and 1000 km, are described in section 4.

2. Principle of Operation

The peak-to-average power ratio of a standard SSB radio telephone output is about 14.5 dB. This figure is obtained when saturation of the power stage is allowed about 1% of the time (3). This means that the maximum power capability of the transmitter is rarely attained when voice is being transmitted. When noise is encountered, the high-level syllables of the voice can be understood but the low-level syllables are masked, degrading the intelligibility of transmitted voice.

The Syncompex system circumvents the above mentioned difficulty by increasing the amplitude of the low-level syllables so that the dynamic range of the transmitter waveform is reduced, allowing all the syllables to be transmitted at or near full power. In this way the low-level syllables can be heard as well as the high-level, thus improving the voice quality at the expense of increased average power (In the experimental Syncompex unit the increase in average power is measured to be of the order of 5-10 db).

The system consists of two variable gain audio amplifiers, one attached to the transmitter called the compressor, and one attached to the receiver called the expander. The function of the compressor is to reduce or compress the dynamic range of the voice. This is achieved by increasing the gain when a low-level syllable is encountered. The function of the expander is to perform the opposite function, that of increasing or expanding the dynamic range, thus restoring the voice to its original form. This process requires the expander and the compressor gain changes to be time synchronized, and the amount of expansion of the receiver to be the reciprocal of the amount of compression in the transmitter (i.e. when the instantaneous gain of the compressor is N, the instantaneous gain of the expander is 1/N). The total system gain of the Syncompex is always unity when synchronized and is therefore transparent to voice and other analog signals passing through it. By allowing a radio system to operate in a mode approximating "constant net loss", Syncompex provides a feature important when connection with the switched telephone system is required.

The instantaneous gain of the compressor is limited to $N=2^Y$, $Y=0,1,2...7$, and is held constant during an entire syllabic interval. Therefore it is necessary to transmit one value of Y per interval to maintain synchronization of the expander. This is achieved by transmitting a digital signal using frequency shift keying (FSK) in portions of the audio spectrum pre-empted from the normal voice signal. The bit timing of the digital signal is used to define the precise time at which the gain change in the compression process occurs. The digital signal is referred to as the control channel.

Syncompex improves voice quality because low-level syllables are reproduced in the receiver with the same fidelity as the high-level syllables. This effect is most noticeable during speech pauses in which the expander gain is reduced to a minimum, suppressing the noise during those intervals.

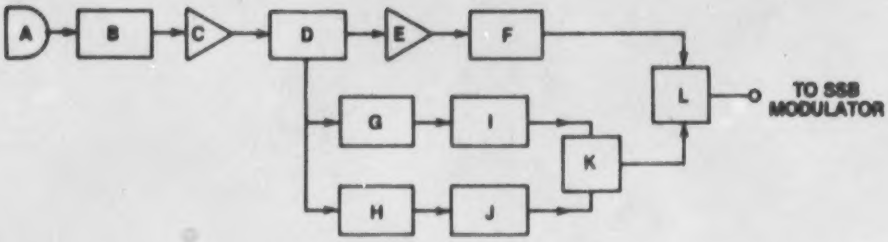
The digital nature of the control channel accounts for the relative insensitivity of the Syncompex system to a limited amount of frequency misalignment between the transmitter and the receiver. The system can operate normally as long as the frequency offsets do not disable the digital demodulation process. This limit was experimentally determined to be ±20 Hz in the existing hardware models. It is possible to use the control channel to obtain a precise alignment of the receiver with the transmit frequency if this is considered to be important. Since the location of the control channel in the spectrum relative to the suppressed carrier frequency is precisely defined, misalignment of transmit and receive frequencies will cause a corresponding shift of the control channel. This principle has been used to implement a visual indicator to facilitate adjustments of the "clarifier" of the SSB receiver. The degree of frequency alignment that can be achieved using the indicator exceeds the control channel requirement and eliminates all traces of distortion in speech due to clarifier mis-adjustment. The process can be automated in a system in which all radios are equipped with Syncompex.

3. System Block Diagram

A detailed diagram of the Syncompex is shown in figure 1A and 1B.

3.1 Transmitter

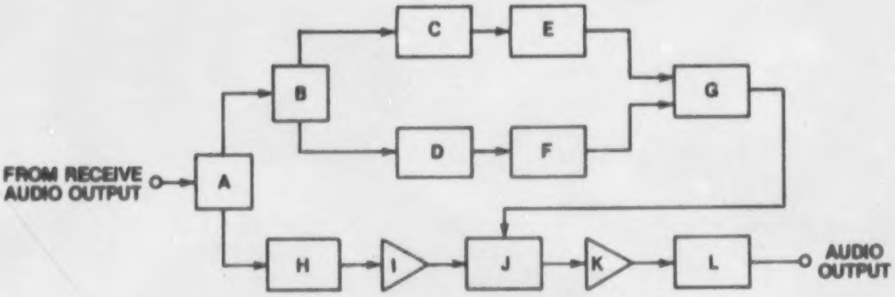
The audio input, after appropriate filtering, is sampled by an analog-to-digital converter which is under the control of a microprocessor. The samples are stored in the microprocessor memory in blocks of 128. An algorithm incorporated into the microprocessor program memory operates to change the gain of each block of 128 samples (defined here as a syllable with duration 13.33 milliseconds). The gain is limited to $N=2^Y$ where $Y = 0, 1,....7$, and the change in gain is limited to 6 db per syllable. (Change in Y between adjacent syllables is ±1). Under the above mentioned two limitations, the microprocessor applies the largest gain possible without causing the output digital-to-analog (D-A) converter to saturate excessively. The D-A output is filtered, forming the compressed


A
B
C
D
E
F
G
I
K
L
TO SSB MODULATOR
H
J

A: Microphone
B: Bandpass filter 300-2800 Hz
C: Analog to digital converter
D: Microprocessor
E: Digital to analog converter
F: Band elimination filter
 - Stop bands at f_1 and f_2 Hz

G: FSK modulator $f_1 \pm 42.5$ Hz
H: FSK modulator $f_2 \pm 42.5$ Hz
I: Bandpass filter $f_1 \pm 125$ Hz
J: Bandpass filter $f_2 \pm 125$ Hz
K: Adder
L: Adder

Figure 1A: Block Diagram of Syncompex Compressor


C
E
B
G
D
F
FROM RECEIVE AUDIO OUTPUT
A
H
I
J
K
L
AUDIO OUTPUT

A: Adder
B: Adder
C: Bandpass filter $f_1 \pm 125$ Hz
D: Bandpass filter $f_2 \pm 125$ Hz
E: FSK demodulator $f_1 \pm 42.5$ Hz
F: FSK demodulator $f_2 \pm 42.5$ Hz

G: Diversity Combiner
H: Band elimination filter
 - Stop bands at f_1 and f_2 Hz
I: Analog to digital converter
J: Microprocessor
K: Digital to analog converter
L: Bandpass filter 300-2800 Hz

Figure 1B: Block Diagram of Syncompex Expander

voice output.

The gain change applied by the microprocessor is used as an input to a pair of FSK modulators operating at 75 bits per second. The FSK modulators use ±42.5 Hz shift between mark and space and are centered at f_1 and f_2 Hz (in the current implementation f_1 and f_2 are in the neighborhood of 1 KHz and 2 KHz respectively). Since the gain change is limited to a 6 dB step every 13.3 milliseconds, a binary channel of 75 bits per second is sufficient to carry the information required and allow the expander to track the compressor.

Identical information is carried in the two FSK channels so that selective fading which disables one channel will not cause the compressor and expander to de-synchronize. Experiments on HF circuits have demonstrated that the use of in-band frequency diversity is necessary for the proper operation of the system.

The portions of the voice band needed to carry the control channel are pre-empted from the output voice band by a filter. The control channel is combined with the compressed (output) voice to form the audio input to the transmitter.

The placement of the control channel displaced from the edges of the voice band facilitates the retrofit of the system to different makes of HF radio by avoiding the poorly defined and widely variable transfer characteristics of SSB filters near the band edges.

3.2 Receiver

The audio output of the radio is split by filters into the three components consisting of the compressed audio and the two FSK control channels. The two FSK channels are demodulated independently and combined to form a single 75 bit per second data output used to control a microprocessor. The compressed voice input after appropriate filtering is sampled and inputted to the microprocessor. Gain changes are applied at the rate of 75 per second in the opposite direction to the compression process. In this way a system gain of unity is maintained. The microprocessor drives a D-A converter whose output, after filtering, forms the audio output.

4. Test Results

A series of tests was carried out between Ottawa, Ontario and Halifax, Nova Scotia and Ottawa, Ontario and Low, Quebec. The distance between Ottawa and Halifax is about 1000 km and the distance between Ottawa and Low is about 60 km. Several frequencies between 3 and 11 MHz were used for the tests. Selective fading was frequently observed during the tests.

The primary test consisted of pairs of live voice transmissions, one of the pair with and one without Syncompex. The peak powers for the two transmissions were carefully equalized to ensure valid results. The time between the pairs of transmissions was kept to less than 2 seconds to minimize the effects of propagation and interference change. The operator at the receiver switched the Syncompex expander in and out as appropriate. The receiver audio was recorded in each case for subjective comparison.

Calibrated attenuators were inserted between the transmitter and the antenna to adjust the transmitted power of the link between pairs of transmissions. The purpose of the adjustment was to obtain some indication of the equivalent power advantage of the Syncompex system.

The test results can be summarized as follows:

1. A dramatic improvement in intelligibility and corresponding reduction of factors contributing to operator fatigue have been observed. The improvement is largely attributed to the silencing of noise by Syncompex during speech pauses. The listener feels more comfortable because he is more confident that he has not missed a low level syllable which could drastically change the meaning of a sentence. A secondary affect is related to the action of the AGC of the receiver when Syncompex is applied. The receiver gain does not fluctuate excessively during a speech pause because of the presence of the control channel. This leads to more natural sounding speech.

2. The improvement offered by Syncompex is dramatic for circuits that have marginal signal-to-noise ratio. When the signal is strong, a slight impairment in voice quality can be noticed. This is due to the loss of spectrum pre-empted for the control channel, and to distortion which results from the quantized nature of the companding process.

3. The Syncompex voice processing is judged to be equivalent to about a 10 db increase in transmitter power. This number is approximate because it is based on subjective judgement and is also dependent upon propagation conditions which varied during the tests. More precise evaluation would have to be made on statistical bases requiring more data than presently available. It should be noted that the HF-SSB radio used as a comparison reference does not incorporate more conventional voice processing techniques such as clipping or RF compression.

4. Some tests were made with a Syncompex model having only a single control channel (4). The performance of this system was judged to be unsatisfactory because of its inability to withstand selective fading due to multipath (5). When fading conditions were encountered the single control channel was disabled intermittently causing sudden changes in the received audio level. Test subjects registered strong disapproval of this type of distortion because it sounded "unnatural". In some cases listening discomfort during selective fading was so acute that subjects reported that they preferred to sacrifice intelligibility. Since multipath conditions are frequently encountered, in-band frequency diversity to counteract selective fading is considered to be a necessary part of the design, and current versions of Syncompex include a dual control channel.

There is sufficient evidence that Syncompex can offer worthwhile improvement in performance to HF-

SSB radio telephone systems. Further development is in progress to produce a design suitable for quantity production.

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The Economics of Communicating Behavior (1)

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Abstract

This paper seeks a common ground of inquiry for the communication scientist and the economist. In recent years the work of these two disciplines have become increasingly interdependent and converging on issues that may believe will determine the nature of future societies.

The Economics of Consumer Behavior

The theory of consumer behavior generally assumes that the preferences, tastes, and wants of the consumer are given data for economists. Rarely does economic theory concern itself with human behavior except in a macro-economic sense when dealing with advertising. It is assumed that advertising expenditures will rise as long as there is a return on the advertising investment. In so far as advertising is communications, this is a measure of communications investment designed to alter or create attitudes that will lead to desired consumer behavior.

Some economists have been concerned with a deeper characterization of behavior. Galbraith has argued that as society becomes increasingly affluent wants are increasingly created by the process by which they are satisfied. Advertising wants "come to depend on output". In Galbraith's words this has a very serious economic consequence since we can no longer assume that "welfare is greater at an all-round higher level of production than at a lower one". (2)

Liebenstein uses such terms as bandwagon, snob and Veblen effects to define theories of consumer behavior. (3) Liebenstein is concerned with .."a reformulation of ...static theory of consumer's demand while permitting the relaxation of one of the basic implicit assumptions of current theory-namely, that the consumption behavior of any individual is independent of the consumption of others." In communication terms, Liebenstein is concerned with the behavior of individuals responding to face-to-face interpersonal communications as well as mediated communications, i.e. communications via radio, television, and the telephone.

Economists often dismiss the details of consumer behavior while recognizing that such behavior has complex psychological and sociological constructs. They believe that for their purposes they can legitimately abstract from these psychological and sociological elements sufficient understanding to enable them to address their attention to the effects of these factors on consumer behavior and on the demand function.

Beginning with the early work of Machlup and now with the recent efforts of Porat and others, emphasis has shifted to defining and analyzing the information sector in order to show the changing nature of our society as it evolves towards an information society. This shift away from the work of Galbraith, Liebenstein and Veblen on consumer behavior, of Marschak and Simon on decision processes and of Arrow and others on information activities of economic organizations has attenuated if not broken the link to the communication sciences.

The Economics of Communicating Behavior

Communication science, as now practiced by the many schools of communications, is primarily concerned with communicating behavior. This includes matters concerning speech, linguistics, rhetoric, meaning, attitude change as a result of communicating, message impact, impact of the mode or media of communicating, (i.e. the channel, face-to-face or mediated by telecommunications or print technology) and the processes of behavioral change to adapt to or adopt innovations. Recently communications scientists have broadened their scope of inquiry to include organizational communications that lead to decision making and management practices, the design of information systems and computer-communication networks, data base management and human interaction with the communication technologies including, of course, the computer. It is through these new interests that the communication scientist must build a bridge to economics. Communicating behavior in these environment can, to a significant extent, determine communicating efficiency, shape resource allocation, and determine costs. However, there is, as yet, no well defined link between the communication scientist and the economist across this most important chasm.

Generally communications scientists are concerned with communications equity rather than efficiency. Their focus on human behavior and their often defensive posture in the face of technology and market pressures have led them to opt for policies that are more humanistic than materialistic. On the other hand economists and their technology allies appear strive for efficiency in both design and market structure. Increasingly communications scientists will find that they will have to be concerned with communicating efficiency and the economist with the economics of communicating. Behavioral scientists seeking to influence the patterns and styles of adoption of new technologies must develop strategies that are both sensitive to human needs and efficient. Economists seeking efficient application of the new technologies must understand and become sensitive to the micro-economic aspects of behavioral change in order to achieve the productivity gains they seek. The two disciplines must meet on the common ground which we call the economics of communicating behavior.

Rural Telephones & The Economics of Communicating Behavior

Several examples that illustrate the need for the convergence of these two disciplines on this common ground are in order. Consider the problem of identifying the benefits of the telephone to rural areas of a developing country. Investments in telephone communications by developing countries are usually made on the basis of a faith that the benefits achieved by the developed nations will, somehow, also be available to the developing nations. While benefits in the industrial sector can be measured almost entirely on the basis of the tariffs business and industry will pay, it is difficult to identify benefits to the rural areas in the same way. Indeed, rural telephones are almost always underwritten through development loans or internal cross subsidies.

A reason for this dilemma is that the question of benefits is posed in terms of communications rather than in terms of communicating. Communicating is a process that begins long before the telephone is used as an instrument in that process. The decision to use the instrument is often incidental to the decision to obtain or transmit information, to facilitate one or more transactions that may bring pleasure, profit, education, or power. As Machlup has pointed out, the overwhelming part of human knowledge and the information processes by which it is distributed is not action oriented. "It serves to teach, to please, to entertain, to improve skills, to satisfy curiosity and to induce a more refined style of living." (4)

The benefits of the telephone must be considered in the context of the total communicating process-what went on before the call was made and what goes on after the call is completed. Benefits cannot always be identified as simply the completion of a transaction. The calculation of benefits must be derived from a consideration of the extended human activity in which communicating may have only been a part and the use of the telephone but a small instrument in that activity. Communication scholars often forget that while communicating is a necessary requirement for the performance of all human activities, it is hardly a sufficient condition for performance.

Broadcast Policy and the Economics of Communicating Behavior

Consider now the several important issues in the reshaping of broadcasting in the United States, those of viewer choice or diversity. Critics of broadcasting argue that broadcasting offers only mass programming without consideration of minority tastes. Choice, diversity, tastes are value laden words seemingly more understandable to behavioral scientists than to economists.

Economists construct economic theories of program choice. Under assumptions of viewer preferences, program costs and broadcast institution structures, models attempt to predict program patterns and compare the extent to which viewers receive preferred programs. For example, the Owens et. al. model, based upon earlier work of Hotelling, Rothenberg, Steiner, McGowan and others is one that is "particularly sensitive to the nature of viewer preferences." (5) These preferences are defined in economic rather than behavioral terms. For example, Steiner defines viewer satisfaction as the maximization of viewers for a given number of channels. An alternative approach might be to describe a mix of program costs and channels that minimizes the probability of a no viewing choice. Owens, perhaps, reaches closest to an appreciation of the communicating behavior of viewers by recognizing that viewers have a first, second, third and a fourth or no viewing choice and seeks, by way of his model, to maximize the number of viewers who choose to watch (or minimize the no viewing option).

In the light of our knowledge of communicating behavior, this is a very weak approximation of viewer behavior & preferences. Simulation models such as those developed by Owens and others require behavioral models in order to make meaningful input to the important policy decisions currently shaping the nation's broadcast institutions.

While economists are content to use money as the primary means by which consumers express the intensity of their program preferences, communication scientists are seeking an alternative language with which consumers can express their qualitative reactions to programs. Unless these two views meet we are left with the dilemma that pits economist versus communication scientist.

The communication scientist would rather deal with questions of diversity, but the economist finds diversity a value laden word and would rather deal with seeking efficient ways of offering the viewer choice. The policy dilemma is joined when the communication scientists observe that the choices that may emerge from a competitive market model for program distribution will not offer diversity, that is, it will not meet the communicating needs of significant segments of the viewing audience. In short the efficient solution of the economist may not be equitable.

The Economics of Innovation Adoption

Consider the questions raised by Arrow in his study of organization behavior in the face of information uncertainty. He points out that while processes other than price adjustments are possible, any feasible process can require only a finite and indeed limited number of steps. It cannot achieve an allocation of resources that would be optimal in the absence of information costs. There is the need to explore the trade-offs among information transmitting costs per step, the number of steps and the resource efficiency level achieved. (6) What has been omitted is the explicit recognition that communicating behavior in the information flow process may be a very critical factor in the costs incurred and number of steps required. While communication scientists have long been concerned with the human processes involved in sending and receiving information, the recent explosion of computer and communications-aided decision support systems has illuminated the need for improved matches between the information "machine" and its human operator. For if this match is inappropriate the information transmittal process will be inefficient and could lead to wasted resources.

Communicating behavior is determined by many factors that significantly influence economic activity. Message content and design, the quality of the software used in computer processing, the degree to which the user of the device is familiar and comfortable with the device will impact how well (efficiently) the system is used, if used at all. Human behavior determines the speed with which innovations are adopted as well as the extent of their use. The information economy will be based upon innovations in telecommunications and informatics, innovations that will require altered behavior of both individuals and organizations. The demand for information and information machines will depend, at least in part, on the rate at which communicating behavior adapts and develops.

There are barriers to the adoption of new information technologies and processes. Overcoming these barriers often requires significant investments in both capital and labor. Training and training aids are needed, certainly the time of many persons in the target organization and of new change agents may be required before they are prepared to accept an innovation that might be foreign to their established ways of thinking and working.

There are several models of the innovation process considerable research has been performed on how this process is facilitated in developing nations, in agriculture (7), and in the acceptance of new drugs by physicians (8). More recently, research focusing specifically on the adoption of telecommunications and computer innovations has identified those factors that appear to be the steepest barriers to change (8). They include, for example, the status of knowledge about the technology and its engineering, the attitudes of the potential adopters concerning the values they assign to the technology, how complex the innovation appears to be, how relevant the technology is to the problem to be solved and how compatible with existing procedures. In some research, multivariate analyses have identified the most significant factors for the specific innovation in a given social situation (9).

These models and measures have important economic consequences. If the communications scientist can develop an implementation strategy that selects the most appropriate measures to use in order to overcome the most serious barriers identified, there could be significant cost savings. If the objectives to be achieved by the proposed innovation are formally stated, for example in terms of the desired costs to be saved or productivity achieved, the communication scientist could develop a methodology that could minimize the time for confirmation or, conversely, significantly increase the rate of adoption.

Combining multivariate analyses that identifies the most important barriers to adoption with the economics of communicating behavior through the appropriate use of cost-benefit analyses, simulation and other methods of cost and budget analyses will have an important impact of the innovation process. This could be the common ground of successful cooperation between the communications scientists and the economist.

Conclusion

The economics of information focuses on processes in which communicating behavior is important; decision processes and decision making, organization development, innovation, demand for information goods and services, advertising, technology transfer, information seeking, etc. These behaviorally sensitive processes cannot be buried by a macro analysis for they are important factors contributing significantly to an efficient solution to resource allocation problems. Economists can no longer be guilty of Myrdal's slap that they "are generous in stating general reservations about the importance of 'non-economic' factors without, however, letting this change their approach" (10). The information society will require explicit consideration of the economics of communicating behavior.

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The Economics of Information as Resource and Product

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Abstract

New computer and telecommunications technology is making it profitable to generate and sell types of information that heretofore was unattainable. Some characteristics of information as an economic resource input into production processes, and as a marketable commodity, are examined. Implications of the market incentive to maximize the dispersion of certain kinds of information, and maintain a restricted monopoly on other kinds, are pursued. Some potential problems for international communication, and international economic development are introduced.

1. INTRODUCTION

The functioning of society depends upon information and the efficient and effective communication of it among society's members. In the broadcast sense, the social, cultural, political and economic institutions in any society are defined in terms of the characteristics of the shared information within those institutions. In the narrower economic sense, it has been recognized generally that the most important resource determining the economic efficiency of any economy, industry, production process or household is information and its effective communication. The characteristics of information define the state of knowledge that underlies all economic processes.

Yet, traditional economic theories and models that purport to explain corporate decisions and government policies do not recognize the characteristics of information as factors to be incorporated in decision-making(1). The state of information and knowledge is assumed to be given. All information necessary for the functioning of economic systems and the taking of optimal decisions is assumed to be available, accurate and costless. In fact, the decision-maker is assumed to be omniscient with perfect knowledge not only of his or her own future, but also that of everyone else. Thus, the problems and implications relating to information are effectively assumed away. The focus of economic analysis is reduced to the mechanics of abstract logic and mathematical calculation. In recent years, there has been a marginal improvement whereby attempts have been made to incorporate uncertainty into traditional economic analysis(2). These attempts have recognized that information is not costless, but rather is sought by decision-makers on the basis of the benefits and costs of seeking information to reduce the uncertainty. But even here, the benefit-cost analysis is based upon an assumption of perfect knowledge of the benefit and cost functions for seeking information. Contributions to a better understanding of the economics of information have taken the form of specialized studies and analyses that have not been incorporated into mainstream economic analysis(3).

In the field of communication, the characteristics of communication processes are examined, but the traditional theories and models tend to ignore the economic characteristics of the communication and information generating processes, even when these processes clearly involve the creation, or manufacture of information for sale as a commodity. Hence, areas of study such as communication and development are built on Western models of psychological and sociological behaviour, while failing to consider the implications of economic institutions, relationships and incentives(4).

Now that entire industries and major sectors of technologically advanced economies are devoted to information -- the search for it, the creation of it, the manufacture, storage, classification, summarization, selection, editing, interpretation, hoarding, purchase, sale, and broadcast of it -- the economic characteristics of information belatedly has been recognized as an area in which precious little is known.

Some authors believe that society is moving beyond industrial capitalism to an information-based economy(5). In fact, detailed investigation certainly would show that societies have always been information-based. The oral traditions of the most primitive tribes were rich in information. The changes of recent years have been primarily in the market characteristics of information. First, the technology of generating, processing and transmitting information at drastically reduced unit costs has provided quantum leaps in the capacity to supply information. Second, in the real economic markets -- if not the economic theories -- it has been discovered that many kinds of information heretofore not provided through formal market systems, have high exchange market values. It is now profitable to search for many new kinds of information that, in times past, was not sought because it was not profitable. Information that previously was outside the market and not included as economic activity, has now been drawn into the market. For example, in North America, telephone users must now pay a direct charge for information operator services. Third, the definition of information has been expanded to become virtually all encompassing.

I suspect that the most significant change between technologically advanced society today and the oral tradition of the Greek city-state -- still practiced by some native cultures today -- is not in the role of information in society, but in the way that information processes have been institutionalized. The dominant form of information creation and exchange has shifted from oral discourse flowing outside the bounds of formal market arrangements to the institutionalization of information generating organizations, the commoditization of information, and its sale through markets. This paper explores some implications of information as a resource input into the production process and as a product, or commodity manufactured for sale

2. TELECOMMUNICATIONS TECHNOLOGY AND INFORMATION SERVICES

The rapid rise of information markets is made possible by the interaction of advances in computer and telecommunications technologies. Advances in the computer industry have pushed back the intensive limit of the market by reducing the costs of generating more and more kinds of data. Advances in telecommunications have pushed back the extensive geographical limit to encompass global markets. However, it is important to distinguish the economic implications of the new technology facility systems that provide the infrastructure within which information is generated and processed, and over which it travels, and the information services themselves, i.e., the content that is provided over the facility systems.

In the narrow economic sense, the facility systems of computers, satellites, cables, terminals, etc. are no different, as a production process, than any other production or manufacturing process. Equipment is manufactured and sold in the marketplace in the same manner as other major equipment. The direct economic benefits are the traditional ones of profit, employment, market share and opportunities for future growth. What renders the facility systems important is that the information services must be provided over them. Therefore, the efficiency of the facility system is a significant factor influencing the efficiency of the information services provided over them. A nation with an efficient facility system may have major advantages that will cut across virtually all information services.

However, the direct implications for society of new information will be determined primarily by the information services that are provided over the facility systems. It is these services that provide types of information that heretofore were unavailable.

3. INFORMATION AS A RESOURCE

Information is often regarded as something equivalent to a natural resource, i.e., a motherlode of objective, unbiased facts to be sought out by diligent search. For example, this view underlies such concepts as "freedom of the press" in Western democracies. Although the press has been recognized as having biases of its own that influence the direction of its search, the information that is found and how it is interpreted, there is a classication of information that can be analyzed usefully as having the characteristics of a primary resource.

The stock of knowledge in society, the skills and education of the populace, the detailed factual information relating to such things as the working of production processes, the interrelationships and interdependencies of different sectors of the economy, etc. represent a primary resource. The value of this stock of knowledge to society depends upon how pervasively it is spread throughout that society and upon the institutions for maintaining, replenishing and expanding the stock of knowledge, i.e., its educational and training system and research generating new knowledge. Economic benefits come in the form of improved decision-making throughout the economy.

Once information has been generated, the cost of replicating it is very much lower than the cost of generating it in the initial instance. The consumption of information by one user does not destroy it, as occurs with almost all other resources and products. The information remains to be consumed by others, the only additional costs being those associated with bringing the same information and additional consumers of it together under conditions where it can be consumed, i.e., learned. And once a given level of penetration is reached, a multiplier effect comes into play with many types of information, as the information is spread throughout society outside the formal processes of learning and training. Hence, although the costs of adding to the stock of knowledge may be very great, there are generally very significant economies in spreading that information throughout society, and to other societies, if the incentive exists to do so. The implications of this economic characteristic of relatively low cost replication of information can be extremely beneficial under some circumstances such as the spreading of knowledge, but it creates special problems and difficulties under other circumstances which are pursued later in the paper.

In the new age of information, much of the information that has become important as a resource input to industrial and commercial production processes is specialized information sought to provide "inside" knowledge of the behaviour of purchasers of a firm's products, suppliers of a firm's other resources, competitors, government regulators, etc. In essence, in imperfect economic markets, this inside information for private consumption strengthens the negotiation and marketing position of the firm(s) or government agency(ies) that have access to it. Such information may or may not be costly to obtain, but its economic value clearly lies in its scarcity, i.e., in the monopoly of information. Once such information becomes generally known to all interested parties, its economic value dissipates drastically.

Specialized information services for the private consumption of a restricted clientelle are springing up almost daily. They range from special research studies of the details of international markets for a group of multi-national corporations to confidential assessments of the negotiating strength of a specific customer, competitor, labour union, or government regulatory agency for a specific negotiation. Because of the low cost of replication of such information -- usually the cost of using the nearest xerox machine -- and the relative ease of information theft, which does not require the physical removal of the information, the value of such information can be extremely tenuous without extreme security. The same economies of information replication that can facilitate the spreading of knowledge throughout society can lead to the rapid destruction of the economic value of many kinds of specialized knowledge.

4. INFORMATION AS FINAL CONSUMER PRODUCT

The characteristics of information as a final consumer product vary depending upon what kind of information is desired, by what users and for what purposes. Perhaps the greatest potential expansion of the information market now underway is for specialized data that can facilitate decision-making, e.g., shopping selections; permit greater efficiency in the performance of certain activities, e.g., banking; and provide new forms of entertainment, e.g., video games. The combination of specialized data banks, computer programs and advanced telecommunication systems make possible individual access through the market to specialized information for private consumption. The economic incentive for the act of promotion and expansion of such systems is very great, given the drastically reduced unit costs of adding subscribers to systems already established.

The new technologies also make both possible and economic the creation of specialized data banks of detailed personal information about individuals for selected users, e.g., credit bureaus, government agencies. In many instances, the market value of this information is greater if access to the information is restricted. This has raised concern that the new market conditions for information make it both profitable and efficient for invasions of personal privacy.

Many governments already have taken steps to attempt to restrain the march of information markets into the details of people's personal lives and to regulate the conditions of access to certain kinds of data banks, e.g., credit, medical and tax files. The pursuit of, sale and use of information in accordance with the incentives of the marketplace apparently is not going to be unrestricted. The flow of information will not be determined solely by the so-called "free market", but rather tempered by government regulatory policy.

The mass entertainment market, most pervasively illustrated by television, takes on somewhat different characteristics. The economies of information replication are very substantial. The costs of copying program information already created is nominal, and the cost of serving larger audiences rather than smaller ones is minimal. With satellites, the additional costs of transmission to greater numbers of geographical locations is reduced to the cost of the receiving terminals. With the new telecommunications technology, the economies of replicating existing information have become almost overwhelming. In addition, the market value of mass entertainment information is not based on restricting access to this information, but in promoting it. Those restrictions that do exist from time to time are tools to maximize profit through discriminatory pricing, rather than attempts to restrict the scope of the market.

News, as a particular form of public or mass information, has very similar economic characteristics to mass entertainment. The major differences are the time sensitivity of the economic value of most news and the fact that most news is sold as an intermediate product by news agencies to distributors such as newspapers and television stations. Finally, we should recognize those unique information markets where purchasers pay to have selective information sent to influence third parties, i.e., advertising. This, of course, introduces a special problem of the quality of the information because frequently the market incentive is to supply misleading information.

5. SOME IMPLICATIONS FOR INDUSTRIAL STRUCTURE AND MARKET DEVELOPMENT

Information markets can be classified into two general categories: (a) those in which maximum market value is achieved by the maximum dispersion of the information; and (b) those in which maximum market value is achieved by restricting information to specialized users who value its scarcity and seek a monopoly of specific information. The former is represented primarily by information provided to the public for mass consumption and is best illustrated by entertainment television; the latter is represented by the generation of specialized information that provides a valuable knowledge differential relative to adversarial interests, and is illustrated by confidential assessments of the strengths and weaknesses of negotiating adversaries.

The maximum dispersion category is characterized by extremely low costs of information replication. With increasing costs for generating original information and reduced costs of replicating it from the previously already low levels, the economic incentives to expand the market for existing information to a global basis are increased. In application, this means, for example, that the economic incentive to dump old U.S. television programs in greater quantities and in more countries is increased. The differential cost to countries without strong domestic television production, of choosing to produce original material at home instead of purchasing American network reruns, is increased significantly.

The second category, markets based on creating a monopoly of certain information, is less influenced by the low costs of information replication, although buyers with similar interests may economize by sharing in certain information purchases. Rather, information generation becomes a focal point for competing interests attempting to obtain a competitive advantage. As such, it imposes a cost on all competitive and adversarial interests if they hope to maintain their relative positions in the market. An opportunity is provided to buy an information advantage. A barrier to entry is created for those who cannot afford to compete at the information game. Since most major market transactions in international commerce ultimately boil down to bilateral monopoly, or oligopoly negotiations, the new information possibilities have the potential for significantly affecting the results of such negotiations. We need only observe the changes in the international oil market when the Arab countries obtained information providing a better understanding of the strong dependency of many developed nations on oil and of the real negotiating power of the oil multi-nationals.

The production characteristics of relatively high costs of establishing most data services and relatively low costs of extending the market for services already created provide a powerful force towards centralization and monopoly. Thus, competitive forces in many information markets are likely to be rather weak. This, in turn, can be expected to raise important issues of government policy, either in the direction of promoting competition, or regulating monopolies.

As a commodity, information can be extremely tenuous. The quality of information may vary substantially. And quality control may be impossible. It is certainly impossible to know in advance whether information you are receiving is truthful and accurate. If you knew, you would not be buying the information. And for many types of information, it will be impossible to assess the quality of it even after the fact. The risks of carelessly assembled, false, misleading and biased information are increased because of the inherent characteristics of information as a marketable commodity.

The extension of the market to encompass information as a commodity also opens a market in its shadow for misinformation. The more valuable formal information becomes to decision-makers, the more devastating misinformation can be. If demands for positive information to enhance a firm or government agency's relative position can be met through the market, then the same objective could be achieved by purchasing misinformation and having it sent directly to an adversary. In principle, a proper economic analysis should assess whether the same advantage could be achieved more economically by purchasing positive information for yourself or sending misinformation to your adversary(ies). Given the difficulties of quality control and the generally lower costs of creating misinformation, as compared to searching for positive information, the misinformation sector of the market could be larger than the information sector. Indeed, the opportunities for profit may prompt the CIA to go commercial.

6. PUBLIC POLICY ISSUES

A major extension of the market to encompass information will raise significant long-term issues of public policy. We can expect much information that previously was available publicly, free for the asking, or obtainable with effort at nominal cost, to be absorbed into the information market system. The new information may be better than the old, but the old information will not be available outside the market system. This, of course, raises important long-term issues of the significance of information costs for the poor, who may not be able to access the information necessary to allocate their limited incomes most efficiently.

The characteristics of information markets create special problems associated with the technological transfer of computer and telecommunications technologies to developing countries. The market incentives are to sell new technology facility systems in developing countries to establish the infrastructure for both the domestic and international communication of information services. Given the established base of information in the technologically advanced countries, and their lead in establishing new information services, the information flows are predictable. Final consumer information such as television programs will dominate the flow from developed to developing countries. Specialized information markets that create value as a result of the monopoly of information will generate a dominant flow of information about developing countries to developed countries and multi-national corporations. Indeed these trends already have been documented(6). These conditions in the information market will facilitate the penetration of developing country markets for the full range of economic goods and services by those organizations that have access to the specialized information. Of course, it will place developing country firms and agencies at an increased competitive disadvantage because of an information deficiency about conditions in their own countries.

Hence, the economic characteristics of information markets are likely to increase, rather than decrease, the dependency of developing countries on developed ones. As Harold Innis explained in his detailed analysis of Canadian economic development, regional development often serves only the interests of the major centres of power because it exploits the staple, or natural, resources of the region. This creates instability and distorted development in the region and dependency of the region on the centres of power(7). In this respect, the market tends to treat specialized information about different countries in the same manner as a staple resource.

Canada, in particular, finds itself in an extremely ambivalent position. As a pioneer in the development of communications hardware, it is aggressively seeking to sell satellite, Telidon and other equipment around the world. At the same time, its domestic telecommunications system is quite inefficient in comparison to the neighbouring U.S. system (8). As a result, knowledgeable Canadian users obtain savings if they use the U.S. system as much as possible. And in the development of information services, Canada finds itself in much the same position as the developing countries. Its mass media is inundated with American information. In the specialized information markets Canada is at a competitive disadvantage. In many industries the United States knows more about Canadian markets than does Canada. And for most information services, the Canadian market is a dependent appendage to the American market.

The situation reached its most ironic extreme to date recently when, while Canadian industry and government representatives were touring the world trying to sell satellite and related equipment and expertise, hundreds of Canadian rural communities -- and some not so rural -- were purchasing satellite receiving stations from U.S. firms to access U.S. satellites in order to receive U.S. television programs. In the great majority of cases, this was being done because of the inadequacy of the Canadian telecommunications system, and the geographical coverage of the television broadcast networks. At present, Canadian government policy indicates much more interest in selling telecommunications hardware in international markets than in establishing an effective domestic communications system and in providing direction to the course of development of the new information services. Nevertheless, the growth of information markets is clearly destined to sharpen and intensify the existing public policy debates now underway in many countries and in international organizations.

As a final observation, we might ask whether in the information society we will have better information than was available in older societies? As measured in quantitative terms, we have more, and we need more facts. However, whether those facts communicate as much relevant information for the needs of society is a different -- and a more appropriate measure. To a significant degree, the information needs are generated by the structure of society. The growing importance and value of vast quantities of factual information in society might be as much an indication of instability of the system as anything else.

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Information and Economic Organization

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Abstract

A prerequisite to the satisfactory formulation of policy towards the information and communication industries is an understanding of the role of information in the economy. In this paper we consider a very important function of information, namely that of organizing and coordinating the economic system. We show that a large proportion of information-related activities serve this objective; there is consequently a need for economic theory to take these informational activities explicitly into account.

INTRODUCTION

The economics of information - the theoretical and empirical study of the role of information in the economy - has been receiving increasing attention in recent years. The interest arose initially because economic theroists saw that an understanding of the effect of infromation, and its absence, is central to the analysis of market behavior. It has now received a further boost as a result of the increasing attention being given by public policy bodies to the information sector - to the telecommunications, data processing, broadcasting and related industries. It is hoped that an improved understanding of the economics of information and the information industries will make a valuable contribution to these policy debates, in both the industrialised and the developing worlds.

Economic theory has only recently addressed itself explicitly to the study of information as a distinctive type of commodity. In 1973 Kenneth Arrow, presenting the customary lecture of the winner of the Nobel Prize in economics to the Federation of Swedish Industries, chose to speak on the subject of "Information and economic behavior". He described information as "an economically interesting category of goods which have not hitherto been afforded much attention by economic theorists" (1973, p.8). The purpose of the address was to "indicate the importance of information as a variable affecting economic behavior and the rather diverse ways in which the economic system is affected by its scarcity and diversity" (p.25). The theoretical literature now referred to under the heading of the Economics of Information concerned with analyzing the consequences of imperfect or costly information in areas of economic theory in which information had previously been assumed to be perfect or costless. Attention was first given to information about prices, following a seminal paper by Stigler (1961), and has since been extended to cover a wide range of "attributes" about which economic agents are uncertain: product quality (Akerlof, 1970), insurance risk (Rothschild and Stiglitz, 1976) and labor quality (Spence, 1974). It has been pointed out that the phenomena of informational deficiency and diversity may have quite profound consequences for conventional economic theory (Arrow, 1973); a satisfactory general model of economic activity in which information needs and activities play a major part has yet to be developed.

Empirical research into the role of information in the economy has been very weak. Curiously, theoretical studies of imperfect information concerning prices, product quality, labor market signals and the like have generally not been backed by data indicating the magnitudes of the informational problems in question. The extent of expenditure on certain specific knowledge-creating and knowledge-transmitting activities, such as research and education, has been researched in detail. However there have only been two major statistical studies of the extent of all information-related activity in an economy, both of which covered the United States. Fritz Machlup (1962) was the first to attempt to measure the share of GNP associates with the production and distribution of knowledge as opposed to other kinds of products. Marc Porat (1977) made a very detailed analysis of the national income accounts with a view to defining and measuring the size of the "information economy". His two principal findings were as follows:

1. The provision of information products and services (either for sale in a market or for internal consumption by firms) accounted for 46% of value added in the economy in 1967.
2. 53% of all labor income in 1967 was earned by workers who were primarily engaged in handling information.

Whereas the exact figures obtained depend on how information products, services and workers are defined, the general message is that about half of all economic activity can be attributed to the production and processing of knowledge or facts rather than of physical goods, and that the proportion is increasing with time. It is this trend which led Daniel Bell to observe that the developed world is entering a post industrial phase, in which "what counts is not raw muscle power, or energy, but information" (Bell, 1973, p. 127).

Porat's study was very successful in drawing attention to the sheer magnitude of information handling activities as a proportion of all economic activity in a modern industrial nation. The findings caused a considerable stir in the communications policy community, and gave rise to an expectation that concrete policy implications would emerge readily from an examination of the newly compiled figures. This expectation has proved overly optimistic. While the fact that some half of our economic resources (at least in the USA) are being spent on processing facts rather than materials is startling, it is not clear what, as a matter of public policy, should be done about it. It is not even clear whether the fact that the proportion is that high is a good or bad sign. There is no theoretical economic framework within which we can interpret and evaluate Porat's principal findings.

THE CONCEPT OF ORGANIZATION

The development of such a theoretical framework will require a clearer definition than is available at present of the major functions fulfilled by informational processes in the economy. Information itself is a very broad concept, and it is not likely that a single model or theory will be able to simulate realistically its many different roles in the economy. In this paper we investigate a very important function of informational processes: that of "organizing" the economic system.

We can think of an economic problem facing society as having two components: there is a technical problem, which is that of producing and distributing goods and services using the limited labor and material resources available, and there is an organizational problem, that of coordinating and organizing the many individual production and distribution activities. The technical problem is one of handling and processing material resources; the organizational problem is one of handling and processing information.

Economic theory has traditionally emphasized the technical rather than the organizational problem. An economy is assumed, in the neo-classical framework, to be constrained by the limited capacity of its agents to produce material goods, not by their limited capacity to process the information which is required to organize and coordinate these production activities. The informational problem of allocating productive resources is assumed to be overcome by the price adjustment mechanism.

Yet the information handling activities associated with the organization of economic activity actually consume a very substantial proportion of a nation's resources. It is possible to make a comparison, based on empirical data, between the quantity of resources spent on productive activities as such - on the production and distribution of economic goods and services - and the quantity of resources spent on the "informational" processes of controlling, coordinating, monitoring, recording - in general, organizing - these productive activities.

The concept of organization is central to the understanding of the economics of information. Every transaction in the economy requires coordination between parties to the transaction, and the coordination is effected by means of information flows. More generally, every activity in the economy must be coordinated with every other activity with which it interacts. The activity must be controlled and monitored so that it fits into the general organizational framework of the economy, and the processes of controlling and monitoring are informational processes. The study of the organization of an economic system can be viewed as the study of the information flows among the segments of the system. Thus we shall try to divide up the economy, in a way yet to be made precise, into two parts: the part which "does" things - which produces, distributes and consumes the goods and services making up a society's wealth - and the part which organizes and coordinates the "doing". The organizing sector consists of the actions of enquiring, directing, monitoring and recording which accompany and control economic activity; the distinctive feature of this sector is that it deals with information - with symbols, words, characters, messages. It uses informational products and services - managerial skills, clerks, ink paper, typists, telephones, computers. Figure 1 illustrates the kind of breakdown we are seeking.

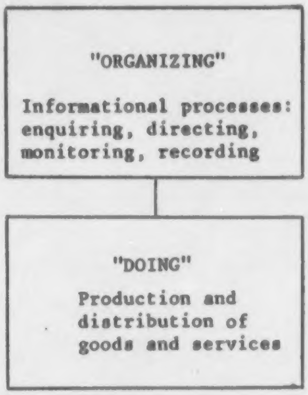
"ORGANIZING"
Informational processes: enquiring, directing, monitoring, recording
"DOING"
Production and distribution of goods and services

Figure 1 A breakdown of the economy.

The organizing sector which we describe here does not include all economic activities which have come to be classified as information-related. Major exceptions are research and development, and education and training. These activities undoubtedly produce an output which has the character of information or knowledge; however they are not concerned, in the sense we require here, with organizing and coordinating the actions of economic agents. The relationship of these informational activities with the part of the economy which "does" things (produces, distributes, consumes) is not directly that of bringing order to the system but rather that of developing the factors of production. Thus a telephone call to a hotel to reserve a room falls within the information sector as we define it here; the knowledge of how to produce better nylon does not. Other examples of informational activities which we exclude from the organizing sector are the work of designers or draughtsmen; while such people undoubtedly supply informational products, the information is not part of the process of coordinating the market economy. By contrast, a line manager in a factory falls into our organizing category. His or her principal tasks are to direct, monitor, record and generally coordinate the activity of other individuals.

The inclusion of line managers and administrators in the category of market coordinators reflects an important feature of the framework developed in this paper, namely that the distinction between "organizers" and "doers" is independent of the nature of the contractual relationships among economic agents. If we observe factory workers following the instructions of an administrator, we may not know whether the workers are employees or self-employed sub-contractors of the firm. In the former case the administrator is their boss, in the latter he is their client. The nature of the administrator's job, and the instructions he gives, are very similar in each case; but if he is a client the provision of workers' services is conventionally regarded as a market transaction (and hence his job as that of a market coordinator),while if he is a boss the provision of the services is conventionally regarded as a non-market activity (and hence his job as one which is concerned with the technology of production rather than the coordination of transactions). We shall regard the activitv as a market activity in both cases, the contract under which the service is transacted being either an employment contract or a service contract.

The task of identifying the pattern of information flows in the economy is made practicable by the very high degree of occupational specialization present in modern societies. We are interested in identifying the resources devoted to organizing the economy - to directing, coordinating, monitoring and recording economic activity. If a person is classified in the labor statistics as a billing clerk we may be reasonably confident that his or her primary functions are to prepare and process bills; these are monitoring and recording activities, and hence the resources spent on a billing clerk's salary fall into the category of expenditure on"organizing" rather than "doing". Conversely if a person is classified as a sheet metal worker we shall assume that his primary function is to work sheet metal, and not to coordinate, monitor or record market transactions; we shall categorize him as a "doer" rather than an "organizer". Sometimes the billing clerk may help to unload a delivery truck (doing not organizing), and the sheet metal worker may fill out timesheets (organizing not doing); but these activities are the exceptions rather than the rule.

A few worker types are more difficult to classify; in these cases it is necessary to make a (sometimes rather arbitrary) choice. An important example of such an ambiguous occupation is that of a foreman. Foremen are classified here as organizers rather than doers; while some of a typical foreman's time is spent doing the same job as his subordinates, the subordinates themselves spend some time on activities which are associated with the transaction with the employer rather than with the job itself (such as keeping records of time spent on the job, or negotiating the employment contract). The work of managers and foremen may be regarded as a proxy for the overall organizational effort associated with the production activity. This example illustrates the fact that the empirical exercise is only intended to be very approximate; it is no more than a starting point for a more thorough study of organizational expenditures.

EMPIRICAL FINDINGS

The results presented below are based on analysis of the matrix of employee compensation compiled by Porat for the year 1967. This lists the wages and supplements earned by each of 422 occupational groups in each of 87 industries; the occupational groups and industries are those used by the Bureau of Labor Statistics and cover the entire economy except for the military.

I have selected 68 out of the 422 occupational groups as being concerned primarily with the functions of controlling, coordinating, searching, monitoring or recording economic activity. Typical examples of occupations selected are managers (and their secretaries), sales representatives, accounting personnel, file clerks, mail handlers and office machine operators. Some of these groups (such as secretaries, mail handlers and office machine operators) are not themselves charged with organizing and coordinating activities (in the sense that a manager or a salesman is) but they directly support these functions. The selected occupations do not cover all white collar or office workers; engineers, designers, architects and teachers are considered "doers" rather than "organizers" in this classification of occupations.

The occupations were divided into ten major groups.

For each major group the total income earned in all industries except federal, state and local government (but including the postal service) was calculated. The total earnings of all personnel in the same industries amounted to approximately $450,000 million; the earnings of the selected occupations summed to $163,000 million, or 43% of the total.

The figures below indicate the proportion of total labor earnings accounted for by each major group.

1. Managers and supervisors	15.9%
2. Professional analysts	0.6%
3. General clerical and secretarial staff	7.5%
4. Accounting and financial staff	5.9%
5. Office machine operators	1.1%
6. Message carriers	1.5%
7. Buyers	0.7%
8. Sellers	5.2%
9. Sales clerical staff	2.5%
10. Brokers	1.8%
Total (rounded)	43.0%

These figures suggest that, on the basis of a simple count of worker types, somewhere in the region of 40% of labor income can be allocated to "organizing" activity and the remaining 60% to "doing" the things which are being organized. I cannot overstress the fact that both the conceptual and empirical basis of this distinction are extremely rough at this stage; we are only looking for orders of magnitude.

We recall that the "organizing" category consists of the actions of enquiring, directing, monitoring and recording which accompany economic activity. Examination of the occupational groups suggests that we can further distinguish between two types of organizing activity. On the one hand there are information flows within hierarchical organizational structures, usually firms. The organizing effort is required in order to control and monitor the individuals within the economic units. On the other hand there are information flows among organizational units, usually between buyers and sellers. In this case the organizing effort is required in order to seek out and coordinate with trading partners and to monitor and record the flow of products and services among the market agents. The distinction is quite fundamental, in that the extent to which activity is organized in the hierarchical as opposed to the decentralized way lies at the heart of the difference between market and non-market allocation processes, and indeed between socialist and capitalist economies.

Within a modern corporate enterprise it is relatively easy to identify the information handling resources which are devoted to each of these two types of organizational activity. The sales staff, the marketing department, and much of the accounting effort is concerned with seeking out, coordinating and recording market transactions. The managers and administrators of the processes of production or provision operated by the firm are organizers of activity internal to the firm. There are obviously some ambiguous categories (especially in top management), but the high degree of specialization of functions in a modern corporation allows most individuals doing information-related jobs to be identified with either the hierarchical or the market organizational functions.

In order to obtain at least a very rough impression of the proportions of organizing effort falling into each of the two categories we shall assume that the occupations covered under the general headings 4,7,8,9 and 10 (accounting and financial staff, buyers,sellers, sales clerical and brokers) are concerned primarily with the market and that the occupations under general heading 1 (managers and supervisors) are concerned primarily with the hierarchy. The occupations under headings 4,7,8,9 and 10 account for 16.1% of total labor income, and those under heading 1 for 15.9%. Allocating the remaining 10.7% of "organizing" labor income (mainly accounted for by secretaries, office machine operators and message carriers) equally between the two categories - we cannot know whether a photocopier or computer is being used for the sales department or the factory division - we conclude that the allocation of effort to market organizing and to hierarchical organizing are at least very roughly similar. The diagram contained in Figure 2 indicates the allocation of labor effort in the economy as we have broken it down so far.

Once again I stress the extremely preliminary nature of the figures quoted on the diagram, which are deliberately rounded to the nearest 10% of national labor income to avoid giving an impression of spurious accuracy.

It is possible, even while working at this level of aggregation, to make a further subdivision within the "information in markets" category. Of the resources devoted to organizing market activity, some are spent on seeking out buyers and sellers (and persuading them to trade) and the remainder on coordinating, monitoring and recording transactions once the decision as to whom to trade with has been taken. Clearly most of the work of a sales representative or advertising agent falls into the former category, while that of a billing clerk falls into the latter. Of the occupational categories listed in the appendix, those grouped under headings 7,8,9 and 10 are chiefly concerned with seeking out and persuading potential partners in trade - usually customers. The correspondence is only approximate; some of the workers in this

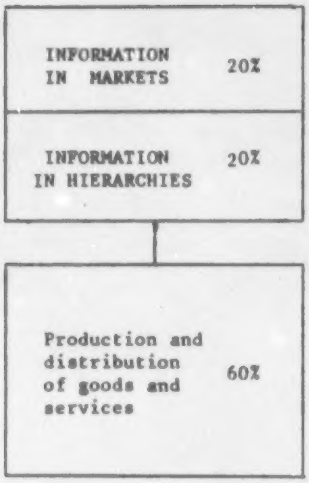
INFORMATION IN MARKETS
20%
INFORMATION IN HIERARCHIES
20%
Production and distribution of goods and services
60%

Figure 2 The allocation of organizational effort in the United States economy, measured by labor input.

group are not market searchers or persuaders, while others who do perform such functions are not included. If we take the size of the occupational groups under these four headings as a rough proxy for the extent of the market searching (and persuading) effort in the economy we find that it accounts for about 10% of total labor income, or about half of the "information in markets" category of organizing activity (see Figure 3).

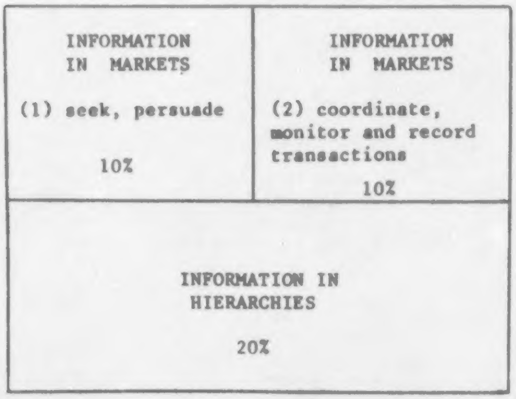
INFORMATION IN MARKETS
(1) seek, persuade
10%
INFORMATION IN MARKETS
(2) coordinate, monitor and record transactions
10%
INFORMATION IN HIERARCHIES
20%

Figure 3 A further breakdown of organizational expenditures.

SOME IMPLICATIONS FOR ECONOMIC RESEARCH

The failure of economic theroy to deal adequately with the related problems of uncertainty and imperfect information is generally recognised to be one of its major shortcomings; indeed many economists believe these issues to pose the central analytical challenge to the profession. In the concluding passages of an essay on the state of economic knowledge Tjalling Koopmans provides the following commentary on this aspect of the failure of economic science:

> "To my knowledge no formal model of resource allocation through competitive markets has been developed, which recognizes ignorance about all decision makers' future actions, preferences, or states of technological information as the main source of uncertainty confronting each individual decision maker, and which at the same time acknowledges the fact that forward markets on which anticipations and intentions could be tested and adjusted do not exist in sufficient variety and with a sufficient span of foresight to make presently developed theory regarding the efficiency of competitive markets applicable. If this judgement is correct, our economic knowledge has not yet been carried to the point where it sheds much light on the core problem of the economic organization of society: the problem of how to face and deal with uncertainty (1957, p.540).

In this paper we have considered the nature of these organizational activities and have investigated empirically the magnitude of resources devoted to overcoming them. We have found that somewhere in the region of 40% of labor effort in the United States economy is devoted to the activities we have described as"organizing", the remaining 60% or so being spent actually "doing" the things which are organized. These figures should be regarded as indicative only. It would be necessary to define much more carefully the conceptual and empirical basis for distinguishing these two categories of activity before attempting to derive more accurate conclusions. What nevertheless emerges without doubt is that, in a developed economy, the informational or organizational activities to which we refer are comparable in magnitude to the directly productive activities on which economic models are customarily focused.

There is a clear implication that economic theory should be reorientated so as to take more explicitly into account the information-related activities we have identified. At the same time more empirical work,disaggregated to the level of individual firms and industries, would help us to build up the database required to guide and test the new theoretical developments. Preliminary work of this kind by the author shows up significant patterns and consistencies, and in particular the following:

1. The relative sizes of the allocations of resources to the different categories of activity

- to "organizing" as contrasted with "doing", and to the different classes of informational activity - are generally consistent with the economy-wide aggregates reported above. For example the figure of 10% as a proportion of economy-wide labor resources allocated to searching for and identifying trading partners in the market is also a reasonable estimate of the proportion of a typical manufacturing firm's outlays which is devoted to sales promotion (including advertising) and product search.

2. Data on organizational expenditure show a remarkably high degree of statistical regularity across firms, industries and economies. After working extensively with data of this kind one cannot help noticing how standardized are the informational activities carried out in diverse businesses. The number of billing clerks per accountant, of secretaries per administrator, of telephones per office worker - indeed practically any measure of the pattern of expenditure on information activities - appears to be very stable across industries. This is due largely to the fact that organizing activities are information handling activities, and there is a very restricted number of ways in which information can be handled. There are a few different ways in which it can be stored (for instance on paper, on magnetic tape, on microfilm, or in the human memory), a few different ways by which it can be transmitted (in writing, in spoken words, in computer code) and a few different ways in which it can be processed (by hand, by electronic machines); that is about all. By contrast there are countless thousands of entirely different processes carried out on non-information goods. There is practically nothing in common between the processes of assembling chairs and mining coal; yet the office layout in the headquarters of a furniture manufacturer may be much the same as that in the headquarters of a mining corporation.

3. While there is considerable regularity in the structure of informational activity in different lines of business, there are clearly identifiable patterns of variation in the overall level of organizational effort accompanying different "doing" activities. It appears that the level of informational effort selected by market agents to accompany a given activity or transaction may be related systematically to identifiable parameters (e.g. value, frequency, competitive structure of the market, scale of operations) of the underlying activity or transaction.

The combination of these three points - the size, the structural regularity, and the systematic patterns of variation of organizational effort, suggests that the development of theoretical models in this area is likely to be fruitful. The regularity in the structure of informational activities suggests that it may be possible to develop simple models of such activities which fit a very wide range of business environments, and that such an exercise may be more valid than the practice of using aggregate production functions to represent the (inreality much more diverse) non-information processes in the economy. The sheer size of the organizing sector makes it of interest even if no satisfactory theory of its origin can be put forward; if 40% of economic activity is accounted for by a few well-defined operations of information processing, communicating and storing, there may be a lot to be learned from a detailed statistical picture of the pattern of expenditure on these operations. The implications for information policy, both in developed and developing countries, are not yet clear; they must await the satisfactory development of theory. It is unlikely that sweeping conclusions - for instance in favor of or against intervention in the information markets as a whole - will emerge. Nevertheless an improved understanding of the role of information in the organization of economic activity will very probably reveal many areas in which policy action can bring about improvements in social and economic welfare. Although the data we have studied are taken from an industrialized country, the implications should be equally applicable in the developing world. In the less industrialised countries the private sector is less able to respond to the new opportunities offered by changes in information technology. Consequently there is all the more scope for policy action aimed at directing the information industries, including the communication industries, of those countries.

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ROLES OF COMPUTERS IN INFORMATION ECONOMIES

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(1)

Abstract

Economic developments of a community is conceptualized as growth in stock of know-how for producing something of value. One role of computers is that of an amplifier and extender in the process of generating know-how to cope with increasingly complex tasks. Another is that of accelerator in speeding the rate of change. The possible effects of computers in these roles upon Pacific area societies are discussed.

1. Introduction

The question of what roles computer-based telecommunications play in economic development was raised at a workshop on the economics of information in June 1980 (2). It was suggested that economic development be measured by the rate at which new production programs are generated (2). Put differently, a community develops economically if its stock of know-how grows (3). A community's economy develops to preserve itself and its members by providing it, first and foremost, with means of subsistence. Subsequently, it may develop its means of meeting its need for security and other needs that stand higher in a hierarchy, such as that of Maslow (4). It may develop the means of meeting higher-level needs with increasingly conscious purposiveness and imaginative planning.

An economy can grow without developing into more complex forms that meet higher-level needs. It develops by adding to its stock of know-how. It uses its know-how to produce new know-how. That can happen only when the amount and quality of existing know-how has exceeded a certain level. When that quality and amount is sufficiently high, then the predominant output is added know-how. We then have an information economy.

Information technologies can of course be expected to play important roles in an information economy. Because of the rapid pace at which computers are being developed and used, it is of special interest to explore their roles. Among the many roles they do and are likely to play we select only two: 1. as amplifiers or extenders in the process of producing and using know-how; 2. as accelerators of the rate of change in development. In what follows, a background in information science, computer science and social science is brought to bear on the discussion. What may be a fresh formulation of the key issues is offered. It is used to describe the present and likely future roles of computers in the development of information economies. The implication of computers acting in these roles upon Pacific area societies is then discussed.

2. Conceptualization of Issues

2.1 Information Economies

Economists characterize an economy by factors of production, such as labor, capital, land and then express the relation between these scarce quantities to be allocated and income as a production function. The simplest possible model can be illustrated by assuming that capital stock, say k units of currency measuring the value of equipment used in production, is the only scarce factor, and that the income it produces, measured in y units of currency per year, is given by

$$y = k/K$$

K is the number of years' worth of annual income that is required in capital stock to produce a year's worth; thus to make 10,000 units per year, 50,000 units' worth of capital stock must be available if K=5.

If it is further assumed that a fraction s of income y is saved, and that all of that is invested so as to increase k in a small time period, then

$$dk/dt = sy$$

and, after substituting for y,

$$dk/dt = (s/K)k$$

The fractional growth rate is

$$dk/k = (s/K)k\ dt,$$

which implies that k grows exponentially at rate (s/K).

An important factor of production that has not been widely used by economists is know-how. We cannot produce a chemotherapeutic agent or vaccine against cancer with all the labor and capital in the world if we do not know how to produce one that is effective. We cannot solve a large linear programming problem in less than a certain amount of time unless we know of an algorithm that is better than those now in use that require the specified amount of time.

Economists often assume, when they write production functions of more than one factor of production, that one factor can be substituted for another. Thus, if we do not know of an algorithm that is as fast as desired, we are likely to obtain one in a few months or years if we employ enough labor or perhaps if we get a faster computer, thus attempting to substitute labor or capital for lack of know-how that is needed just now. This may be true up to a limit and under special conditions. No algorithm can be faster than specified by the computation complexity of linear programming (which is as yet unknown) in a given computational model. No amount of labor or capital is likely to find a "cure" for cancer unless and until the scientific community's level of understanding has reached that critical level at which it can persuade nature to give up its secrets about the mechanisms of malignant growth.

The measurement of the inputs and outputs of a productive process in currency units conceals the know-how and the mechanisms by which currency is used to generate more money. The purpose of production is to meet human needs and accomplish something that is valued. Needs must be recognized. Before they can be met, tasks must be set and knowledge, purpose, affect and social bonds must be organized to cope with these tasks. The results of such coping must be evaluated and utilized if deemed to be of value. It takes know-how to do all that.

Let us call the above, production, and the procedure for producing, a production program, defined as a sequence of instructions, as in a computer program, that embody the needed know-how. In this sense, know-how includes not only cognitive knowledge and understanding, but organization of purpose and will, organization of affect and loyalties as well as political and moral wisdom and humanistic perspectives. Know-how in this sense brings about structural changes in the means of production, consumption and distribution that distinguish between growth and development.

Though it is tempting, and has been tried, to express know-how -- or at least knowledge, as measured by the number of publications or patents -- as a function of time analogous to $k(t) = k$ for capital stock, it does not make sense. The stock of know-how is a qualitative concept. Representing it quantitatively can mislead. A vast and elaborate program, e.g., adding the numbers from 1 to a million by summing 1+2 then 3+3, etc. or for making shoes or for closing a transaction may be based on a procedure of low quality or level, whereas a high-quality procedure may use very few instructions or operations. A few high quality programs may comprise more know-how than many mediocre or low-quality programs, and that would not be reflected in a simple measure such as k.

What can perhaps be quantified is the number of coherent, recombinable independent units of know-how of varying degrees of quality. Let q denote the quality of a unit such as a subroutine in a computer program that has many varied uses. Perhaps q can be interpreted as its brevity relative to its power. An example of a relatively high-quality maxim to guide a person's conduct is the terse but meaningful dictum: "Be kind and cautious." An example from science is Newton's second law: F=ma. If the distribution k(q) is such that there are many such pithy statements pregnant with meaning then we have a great deal of know-how. Possibly some measure of both quality and quantity, e.g.,

$$x = \int q^w k(q)\, dq$$

where w is the weight given to quality, might serve as an index for purposes of analysis. It varies with time, of course.

The most important point of this paper concerns the process by which know-how is used to generate new know-how. If we examine how a creative scientist invents or discovers a new idea, formulates a new problem or finds a way to solve one, we observe a process of synthesis, of "just happening" to think of a unique mix of a few concepts, known results, methods that are just what he needed and right when he needed them. He could not have specified before he encountered them, by recall from his own memory, by interactions with others, by searching or keeping up with the literature, what he was looking for. He recognized them immediately upon encounter. The number of such items is seldom more than two or three at once, since it is difficult to establish and make use of connections among more than two or three at once, since it is difficult to establish and make use of connections among more than two or three things at a time. Yet selecting two or three items from a large set of possibilities is too rare an event to occur by chance, though chance or chance-like mechanisms may play a role. The inventor's mind is so conditioned and attuned to seeing connections and he tends to move in arenas in which there is a good chance of his being exposed to connectable items, that he is not only steering himself toward fruitful encounters, but he is prepared to recognize their fruitfulness. What enables him to do that is know-how of a certain quality and kind.

Assume that the know-how associated with inventiveness and innovation arises when x reaches a certain sufficiently high level. Assume further that know-how after it has reached this level grows at a rate proportional to its level, that is, exponentially. For the reasons we discussed previously -- that meeting certain higher-level needs is know-how rather than labor or capital-limited -- the production of new know-how now becomes the predominant productive activity. We now have an information economy.

But x cannot continue to grow exponentially. The tasks to be coped with become increasingly complex, partly because the most easily met needs are met first and partly because the results of having coped with very many tasks interact and impose constraints with and on the tasks yet to be coped with. Occasional housecleaning and radical restructuring of the organization of knowledge may greatly simplify tasks that were formerly complex. But such changes are likely to be separated by centuries or millenia. Our time horizon shall be limited to the present and the next two decades.

2.2 Complexity of Tasks

Of the many factors that make tasks complex (5), the increasing number of interdependent variables that describe first order effects and the increasing uncertainty of knowing their values is important in this context. We may be witnessing a trend toward a more wholistic approach to meeting human needs. Despite advances in molecular biology and other scientific aspects of medicine, the practice of medicine may well return to concern about the involvement of mind in the healing process, to the importance of hope, will, faith. Despite the advances in operations research and management science, the practice of management may come once again to rely on judgment. This does not imply a reawakening of the vitalist-reductionism controversy, but a broadening of the factual base that is taken into account. Acupuncture does work, even if adequate scientific explanations are not yet available. Some executives have greater organizational talent and some inventors more creative talent than others even if we cannot explain these differences or train people to excel in these ways.

The challenge to coping with complex tasks is due not only to the large number of interacting variables and uncertainties. It is due also to the increasing difficulty of formulating tasks in appropriate ways. We tend to formulate tasks so that we are likely to cope with them with the help of existing know-how. We often fail even to recognize tasks that correspond to lack of know-how for coping with them.

The greatest challenge is to generate needed new know-how. We now ask if computers could help in meeting those challenges.

3. Cognitive Amplifiers

An important role for computers in information economies is to help us cope with complex tasks, to help us improve task-formulations, and to help us add to know-how, at least with the cognitive aspects of these activities. Computers excel at performing repetitive operations at high speed with great reliability, but are poor at combinatorial problems. Tasks requiring tedious mental labor in large volumes are ideal for computers. Knowing this, managers in an information economy will have formulated tasks that can be delegated to computers. Thus we see computers used in the design of oil refineries and most engineering problems. In a less advanced economy, an oil refinery might use as much as 10% of the energy it produces to produce energy. With the help of more sophisticated computer methods and overall perspectives, that inefficiency can be reduced significantly. Efficient design is a hallmark of an information society: it embodies know-how that is added. With the help of computers, operations of a much larger scale and complexity can be analyzed than without their help. The number of operations that a given designer or analyst can handle is greater if he is aided by computer than when he is not. In this sense, his ability to analyze or design is amplified.

With regard to task-formulation, it is evident that certain tasks would not be selected or formulated as tasks in the absence of the idea that a computer would carry them out. The presence of computers generates some of the demand for their use. Many large firms in an information economy -- in the aerospace industry in the United States for example -- have excess computing capacity that they seek to put to good use. Hence, such firms as Lockheed have begun to capitalize on such by-products of computerized composition of publications to provide on-line bibliographic search services. Before too long, we can expect on-line text and picture storage and search. Insofar as each computer with spare capacity provides employment opportunities for programmers, analysts, etc., who formulate new tasks, computers play a role in the amplification of task-formulation effort.

The role of computers in helping us add to know-how is indirect. They change the way we think about what to produce and how to produce, by their existence. They present us with new concepts and new opportunities to connect these with other concepts. We need merely observe the pervasive intellectual influence of the "information-processing paradigm" in psychology to see this. The new points of view stimulated by the issues raised in thinking about what computers can and cannot be made to do give rise to new criteria for selecting what items of know-how to connect.

Office work is an important part of an information economy. Coordination, command and control is a major aspect of office work. There is increasing awareness that office work is less and less productive and efficient. In many Western countries, more of the economy has been shifting to the public sector, and governmental requirements for reports of compliance with proliferating regulations consume an increasing fraction of office work, including the use of computers. Vast amounts of data are collected, stored and occasionally processed that no one really needs or can use.

In sum, a major role for computers in an information economy is to extend the range of tasks that are likely to be formulated and coped with, to expand the number of diverse tasks an individual can cope with and to indirectly add know-how.

4. Accelerators of Change

Computers are very fast, and they are getting faster, smaller, more powerful, more reliable and cheaper, due to very large scale integrated circuit technology. To be sure, there are basic limits, but the same rate of improvement that has been observed so far will probably continue for another decade or two. This great speed enables computers to play other important roles in an information economy. Besides enabling an individual using a computer to perform more of the same kind of tasks that he now performs in a given unit of time -- which is another kind of amplification -- computers play a key role in telecommunications.

The considerable potential of computers to make office work in advanced information economies more efficient and productive has been demonstrated but not realized. Why? It is being widely recognized that the primary bottlenecks are human and organizational rather than technological, hardware or software. Office automation requires both technology and organizational know-how, and that is often absent or not sufficiently recognized or emphasized. Office automation systems must support individuals, and they should be flexible in order to gain acceptance both by individuals and organizations. Each stage should be preplanned. It should be compatible with future stages.

Computer-based telecommunication systems can help to overcome some of the barriers and meet some of the challenges listed above. Variants of matrix management techniques can be implemented with the help of computer conferencing, providing a workable team approach to the organizational obstacles to office automation. It is not merely the point-to-point communication with store-and-forward and retrieval of all past group interactions capabilities that is important about computer-conferencing. It is the realization that people can interact with one another, despite great distances and differences in workstyle between them, both synchronously and asynchronously (using their computer terminal at their convenience and when they are properly prepared) in ways they could not without a computer. An example is informed group decision-making.

But the computer permits a team of people to do more than communicate, cooperate, coordinate, exert interactive command and control among one another. By adjoining to a computer conferencing system, the ability to tap wits external to the group, from the literature for example, or to access an expert on-line knowledge base plus a data analysis package and a programming language for simulation, all made readily usable by nonfluent users through a friendly on-line tutorial system, both an individual's research is speeded up and peer communication and teamwork can be greatly accelerated. An economist, for example, can test hypotheses about the market for a new product in a single, half-hour session at a computer terminal if he has access to a data base with appropriate data -- and these now exist -- an efficient data base management system -- which also exists -- coupled to a statistical package; this might have taken weeks to months before.

More generally, efficient telecommunications can increase the rate at which new know-how is produced and utilized. New units of know-how are coherent patterns (packages of instructions) built with older recombinable units of know-how that are themselves coherent. By coherence we mean that connections among the component parts exist, have been made explicit and used to justify a claim about how to produce something of value. To illustrate, imagine a large set of equations for synthesizing chemical compounds that may in turn be used as reagents or catalysts in other syntheses. A random selection of three such equations is most unlikely to result in the synthesis of a new compound, much less one of value. The resulting triple of equations would be incoherent.

The inventive persons who find suitable triples (or larger combinations) that they can connect to produce a coherent new know-how unit are generally part of a community of peers. An act of invention or discovery is not complete until there is consensus in that community that something of value has been added.

What constitutes value and its recognition depends on the composition and structure of that peer community. The traditional process of peer review -- usually through the published literature -- is very slow. An important role for computer-based communication is to speed it up and perhaps also to improve the mechanisms of peer selection (6-10).

Telecommunication facilities are needed most when there is important information to communicate. Information pertinent to economic development is considered to be important. An information economy at its peak of development will generate know-how of great economic value, and those in a position to utilize it will generate great demand for such know-how and for the telecommunications facilities, over which two-way exchanges about such know-how can take place efficiently. Computers, by providing large random-access storage, high-speed switching and routing control, facilities for data access, display, analysis and good communication protocols in high-level programming languages, will play an important role in the development and use of the needed telecommunication networks.

5. Effect on Pacific Area Societies

The most striking fact about Pacific area communities is their diversity. They comprise some of the world's most developed nations -- information societies such as Japan -- and some of the world's least developed communities. Half of the newly industrialized countries are in this area. If the main reason for grouping Pacific area societies together is that they all border the Pacific Ocean, then the use of telecommunications would seem to invalidate that. Peru may have more need to communicate with Bolivia, and Korea with Iran than does Peru and Korea.

Assuming, however, that countries bordering the Pacific will be interconnected via telecommunications for reasons of geography, politics, or just in error, what implications could be expected if computers play the roles we discussed? First of all, it should be clear that they are likely to be used primarily in communities that have information economies or which are developing into such. The main examples of this are Japan, the newly industrialized countries (Korea, Hong Kong, Singapore, Taiwan) and China (with Australia and New Zealand if these are considered to be Pacific area with the U.S., USSR, Canada and possibly Mexico as well). In such countries, it is estimated that as much as half the work force is employed in work related to the production of know-how or its distribution. Important issues about employment in the face of automation, freedom of information, public vs. private sector balance have been discussed since the announcement of the Japanese Plan for an Information Society by Masuda in 1972 (11). A 100-year extrapolation of present trends, which seems ill-advised, leads to a conclusion that "the computer will be better integrated into our future communication patterns, leading to profound changes in education, politics and other social institutions" (12). A more short-range forecast asserts that U.S. domination of computer technology will be replaced by a condition of approximate parity with Japan (13). Whether this will affect the Pacific area societies to a greater extent than the rest of the world is doubtful; it is not obvious that U.S. dominance of computer technology affected the American continent to a greater extent than it did the rest of the world.

Opportunities for special uses of a regional telecommunications network surely exist. Advance warning of earthquakes, tidal waves, typhoons which are common to the Pacific area should surely be facilitated. Joint ventures in research on problems in climatology, oceanography, plate techtonics, meteorology as well as the social sciences such as anthropology should also be greatly facilitated. Whether such opportunities will be taken and benefit the less developed communities as well depends on factors other than the availability of facilities. Generally, however, opportunities to use available facilities have increased the likelihood of their use.

For the more developed communities, the possibilities of instant mail, electronic money, telemedicine, telewars, teleshopping, etc., have been discussed (14, 15). It has been predicted that only jobs requiring human judgement will be secure from the threat of technological displacement (16). Possibly, however, there will be a flow of highly skilled labor to the less developed countries, helping them to accelerate their rate of development. On the other hand, if these speeds are out of balance with the rate at which deeprooted cultural patterns change, as in the case of Iran, then turmoil can result.

In conclusion, the introduction of computer based telecommunication networks into Pacific area societies should be accompanied by a strong effort to understand the social and economic implications.

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Computer Networks for Asia-Pacific Economy

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Abstract

Viewing information as an essential resource for national and regional economic development, and modern network-based information services as an important potential facilitator of both intra- and international information flows, this study has investigated the growth prospects for such services in the Asia-Pacific region. Survey and interview results from 10 countries reveal that severe supply obstacles and demand limitations exist at present, not only because of direct technical, political, cultural, and economic problems, but more basically because many Asia-Pacific countries have barely begun the development of domestic tertiary sectors. Possible future circumstantial changes are hypothesized, and both short-term tactics and long-term strategies for network service development are suggested.

1. INTRODUCTION

It has long been recognized that "knowledge is power and consequently those who transmit knowledge transmit power" (1). It should hardly be surprising, then, that effective communication is often considered a prerequisite for economic development (2). Any technological advance which fosters the flow of knowledge within and among countries should therefore have at least the potential to accelerate growth. If so, then the combination of modern telecommunications and computer technologies which has produced the current "information revolution" in developed parts of the world should be of considerable interest to economic planners and policy makers in developing countries as well.

Many computer-communication specialists believe that the information revolution will, like the industrial revolution, eventually spread from the countries where it began to the rest of the world. This idea was expressed quite forcefully, for instance, at the Networks 80 symposium in Bombay last February (e.g, 3-4). What is not so clear, however, is how rapidly the revolution will spread, along what paths, or in what forms. Furthermore, because circumstances in developing countries are unlike those in the developed regions where the information revolution began, it may not be entirely obvious what tactics and strategies will be most successful in promoting the new network-based information services.

The purpose of this paper is to offer some preliminary survey results and hypotheses relevant to these questions.

2. BACKGROUND

The research activity from which these results are derived began four years ago at the International Institute for Applied Systems Analysis (Laxenburg, Austria), when a team of American, Austrian, Polish, and Soviet scientists collaborated to create the first computer conferencing links into Eastern Europe. Based on our IIASA experience, we developed the concept of "Computer-Assisted International Team Research", or CAITR, by which we mean the use of modern telecommunications and especially computer-communications technologies to facilitate joint research by scientists who wish to work together but who for various reasons cannot spend long periods of time in the same geographical location (5).

In early 1979, the East-West Resource Systems Institute undertook to continue this work in the Asia-Pacific context and specifically to explore the feasibility of CAITR links among the geographically scattered groups of scientists involved in the institute's substantive research on energy, food, and raw materials problems (6). This feasibility study has included three principal activities so far:

- A pilot survey of 35 scientists and policy makers from Bangladesh, India, Indonesia, the Philippines, Sri Lanka, Thailand, the Trust Territory of the Pacific Islands, and the U.S.A., conducted during a research planning workshop in May 1979.
- Interviews with representatives of 53 institutions (ministries, institutes, libraries, laboratories, corporations, etc.) in India, Indonesia, Japan, the Philippines, Singapore, and Thailand, conducted during January-February 1980.
- Experiments with network use from India and the Philippines, as well as routine use of networks for communication and

data exchange with my former institute in Austria and other institutions in Europe and the U.S. mainland.

Despite the fact that these investigations were concerned primarily with scientific applications of computer networks, I believe that many of my observations concerning Asian realities and prospects may be of wider interest since many of the same problems and options will affect networking efforts of other kinds.

3. ASIAN REALITIES

3.1 SUPPLY OBSTACLES

To begin with, participants in the 1979 survey indicated that at least five major obstacles stand in the way of Asia-Pacific computer networking even if enthusiastic demand is assumed.

The first is lack of terminal equipment. Very few of the respondents' home institutions possess computer terminal equipment appropriate for network use. I later learned that in some countries (e.g., Thailand) not a single dial-up terminal was available as of about a year ago.

Similarly, there is the problem of network access, since Tymnet, Telenet, or other commercial digital networks at present reach only a few Asia-Pacific countries. At latest report these included Australia, Hong Kong, Japan, New Zealand, the Philippines, Singapore, and Taiwan, plus farther afield Bahrain and Israel.

In all but the most developed countries of the region, local telephone circuits are of inadequate quality for data communication and leased lines must be installed at considerable expense.

There is a chronic shortage of experienced personnel, particularly where innovative applications are concerned.

Finally, perhaps most seriously of all, there are bureaucratic institutional constraints often having to do with government permission.

3.2 DEMAND LIMITATIONS

As if these supply obstacles were not bad enough, my interviews in early 1980 revealed an even longer list of reasons why demand for certain kinds of network applications might not be as great as one might have expected.

In some cases, for instance, the needs which network use is intended to satisfy are already being met better in some other way (for instance, by use of local computing power) or else are simply not considered important enough to pursue.

A closely related problem is uncertainty about the cost-benefit characteristics of proposed applications, aggravated by the knowledge that system promoters commonly "oversell".

In many countries there is a resistance to automation, especially any kind which is complex and remote from the proposed users' previous experience.

Inappropriateness for mass use could be another problem, since decision makers (especially politicians) in developing countries must beware the appearance of elitism.

Some respondents raised the danger of "information pollution," which is already known to occur for instance in the use of bibliographical databases, since these commonly provide large numbers of references of which only a few are truly appropriate to the user's needs.

Another problem is that of language, although fortunately for the scientific and managerial elite of Asia English is an acceptable lingua franca.

If transborder flows of data are envisioned, many respondents objected that data of any significance would probably have political or commercial sensitivity as well, and that it would be illegal or at least undesirable to put such data into foreign computers even for one's own purposes (use of special software, etc.).

Several respondents indicated that their countries have, through painful experience, become suspicious of developed country motivations where information flows are concerned, a fact which can only compound their sensitivity about transborder data flows.

Finally, we have the problem that many countries in Asia are both poor and extremely short of foreign currency, which means that no major expenditures for information services are likely unless those services offer fairly direct and obvious contributions to the achievement of national priorities.

3.3 UNDERLYING CAUSES

On reflection it should be obvious that most of these problems derive from underlying causes of various kinds.

In the economic sphere, for instance, lack of money is an obvious point, but lack of sophisticated applications is one perhaps more easily overlooked. Most of these countries for instance have no world-class R&D activities requiring high-powered engineering and design computer capabilities. And even in the area of business computing, the relatively low wage rates in most of these countries imply very different cost-benefit comparisons between human and computer solutions to data processing needs than might be observed in more developed countries.

In the informatics sphere, it is important to realize how strong the in-country computer capabilities of many Asia-Pacific countries actually are, which means that network access to foreign computers will not be necessary for routine computer applications. Even for less routine applications such as econometric modeling, forecasting, decision analysis, and the like, most of the difficulties faced by professionals in these countries are not related to their computer or communication facilities at all but rather to such problems as the lack of data on which to base their calculations.

In the sphere of psychology and/or culture, we find one problem which many of my respondents indicated to be the most serious of all, namely, the yawning knowledge gap which separates the comparatively well-trained user and manager stratum from that of the relatively ill-trained bureaucrats and political appointees. It is not uncommon, for instance, for such bureaucrats even in official correspondence to confuse technologies such as Landsat and Intelsat. Rivalries within and among Asian countries are another important psychological problem, as is the fact that many Asians are accustomed to the unavailability of information and thus are not accustomed to seeking information even if it might in fact be available somehow.

Finally, we have a number of problems in the political sphere, especially the all-pervasive role of national government in most Asian countries and the need which this implies for top level patronage if new ideas are to progress with any rapidity. Such governments are resistant to pressure, although they have been known to yield when domestic business interests can unite in urging a change in policy. In almost every country the governmental bottleneck in questions of data networking would be the communication ministry or equivalent, not only because it must approve any new communication scheme but also because it may itself sometimes have difficulty in obtaining the agreement of other government bodies.

In Figure 1, we see a particularly telling set of relationships concerning the size of each country's gross domestic product (GDP) and the percentage of that GDP which comes from the tertiary sector of the economy. For comparison, the major countries of North America and Western Europe where data communications developments have been most active to date would all be in the upper right-hand corner of this chart, or at worst shading over into the next box to the left. In Asia, however, nearly all countries are in the bottom row, that is to say, poor. And of the remainder, only a few have a very large tertiary component in their GDP. If, as I suspect, the demand for information services of any kind depends quite largely on the extent of a country's knowledge-based economic activities--that is, activities of the tertiary sector--this would suggest that most Asia-Pacific countries will, for the moment at least, have considerably smaller overall economic potential for computer communication services than do the countries of North America and Western Europe. Naturally, there are special cases such as Singapore, Hong Kong, and a few others which because of their nodal position in international communication, transportation, and commerical systems require the most up-to-date networking services.

4. ENVIRONMENTAL FORECAST

Given all of the realities we have discussed, it would be interesting to consider what changes in these circumstances are foreseeable in the next five to ten years. The following views are essentially hypothetical, but they do reflect my observations to date, and I believe that efforts to develop a more comprehensive and reliable set of forecasts concerning the environment for computer communication in Asia would be very much worthwhile.

To begin with, there is reason to expect that the next few years will see a significant increase in the availability of computer networks and terminals in many countries of the region. Figure 2, for instance, show the growth pattern in the set of countries which have installed Tymnet nodes. (Similar patterns probably apply to other networks as well.) Something like saturation in the developed parts of the world may have been achieved already, whereas in areas such as Latin America and especially Asia and Oceania, the number of countries has increased very rapidly in the past three years and shows no sign of slowing yet.

Growing use of quantitative data and analytic methods in the decision-making process by both government and business will increase the need for information support systems of various kinds. Increasing international standardization of data-handling software and formats will increase possibilities for convenient data exchange. And at the same time, the cost of alternative (non-electronic) information access mechanisms such as travel and book-buying will inexorably mount. All of these trends, if correct, would seem to favor both national and international computer networking efforts.

On the other hand, there is also reason to believe that the cost of local computing in many Asia-Pacific countries will decrease. Local expertise will increase. Data communication tariffs will be "sticky downward"--that is, even if the cost of data communication goes down, the local telecommunication authorities may be disinclined to pass the savings along to the customers. And finally, there will be greater, not less, nationalism and protectionism in the region as international tensions and instability increase under the pressure of population growth and resource depletion.

So in short, I suspect that the demand for computer-based information services will rise as the technical competence and sophistication of many Asian countries rises, but at the same time this very growth in technical sophistication will increase many countries' ability to satisfy those demands locally without the use of networks of any kind.

		% GDP FROM TERTIARY SECTOR		
		< 30%	30-49%	≥ 50%
GDP (U.S. $ x 10^9)	≥ 50	SAUDI ARABIA	INDIA IRAN	AUSTRALIA JAPAN
	20-49	PHILIPPINES	INDONESIA REP. OF KOREA	
	< 20	(7 COUNTRIES)	(11 COUNTRIES)	(11 COUNTRIES)

SOURCE: U.N. STATISTICAL YEARBOOK, 1978

FIGURE 1. ECONOMIC POTENTIAL FOR COMPUTER COMMUNICATION SERVICES

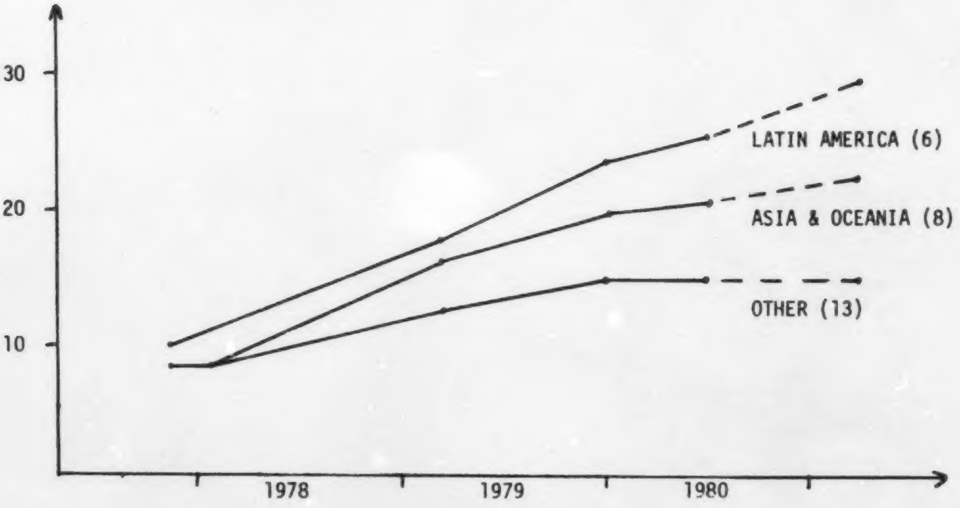

FIGURE 2. NUMBER OF COUNTRIES WITH TYMNET ACCESS

The exceptions I suspect will include:

- Services which truly must be international (that is to say, those which are communication-biased).
- Those which have high value of information for their users but are needed only sporadically and therefore are not worth creating in-house.
- And finally, those which are valuable, unique, and difficult to duplicate. These criteria might apply to extremely sophisticated analytic tasks which nevertheless have relevance even to the less developed countries, such as the analysis of data from remote sensing satellites.

5. SHORT-TERM TACTICS

Now let us turn to the question of the tactics which information-service promoters and their interested customers may be able to pursue in the short term.

5.1 REMEDIES FOR SUPPLY OBSTACLES

In some cases, conventional terminal equipment is being acquired by potential end users, but in its absence, low-volume users might access the international networks through Telex terminals via gateway nodes in New York. Also, end users may be able to obtain service through local information retailers--in the way that, for instance, Philippine consumers have been able to work through the Technology Resource Center in Manila.

As to international network access, acquisition of a node on one of the commercial packet-switched networks is of course ideal. In its absence, the Telex option may be attractive, or it may be necessary to dial direct to a network node in a nearby country.

For the local loop, private lines seem to be the only solution, and if the end user is at a great distance from his country's network node(s), it may be necessary to create special types of links, like the five-channel UHF system installed by the International Rice Research Institute to link their offices in Los Banos (Philippines) with Manila. Failing that, it may be necessary for inquiries to be made by voice and for hard-copy output to be returned physically to the end users by the local information retailer.

In the short term, shortages of skilled personnel can perhaps best be dealt with by repatriation or secondment, unless time can be allowed for sending key staff members abroad for training.

Bureaucratic difficulties will require patience, acceptance, and insofar as possible the currying of patronage.

5.2 SHORT-TERM MARKETS

International network applications for which markets seem promising in the short term include, first of all, some which exist already but do not reach all of the countries of the region, such as: the airline reservation system offered by SITA; the interbank communication system offered by SWIFT; access to U.S. databases of the kind offerred by Lockheed and SDC; on-line fault reporting and diagnosis of the kind that IBM is now creating in Southeast Asia; and the linking of overseas branches of U.S. firms to their home offices in the United States.

Another set of possible network applications which do not currently exist in the region so far as I know but are at least reasonably familiar to the potential users and would therefore find a comparatively ready reception include computerization of the news wire services; computerized access to commodity and stock price data bases; access to Asian databases, such as the very interesting business and energy data being compiled and now made commercially available by the Nikkei newspaper (Japan's Wall Street Journal); internal communication within the structure of certain international organizations such as the United Nations (perhaps ESCAP) and the United Nations University in Tokyo; and also the interesting pattern of linking overseas branches of Asian firms to their home offices, this being an expressed need of Japanese firms with U.S. subsidiaries or sales outlets.

Aside from all these international network applications, we have evidence about the types of domestic networking applications which might be suitable for countries whose economic development follows the Japanese path as many Asian countries intend to do.

For the Japanese example, we find that in the first phase (five years or so) of data networking, the number of different applications is quite small, and they have a very practical and not very complex nature, such as railway seat reservations and local interbank data communications.

In a second phase (again about five years long in the Japanese example), somewhat more sophisticated services are added, for purposes such as scientific and engineering calculation and sales and inventory management.

6. LONG-TERM STRATEGIES

6.1 NEW OFFERINGS

Turning now to the question of longer-term options, I would suggest that there a number of types of new international information service offerings which may be even more appropriate to the needs of Asia's far-flung and often poor countries than the ones we have discussed so far. Examples include:

- Informational clearinghouse operations to provide current awareness information about meetings, research projects, publications, etc., relevant to pressing policy issues for the region.
- Data resources and referral services, which would help investigators in these countries determine whether and where information might be available pertaining to their problems.
- Conferencing services as a substitute for long-distance travel.
- Hybrid systems, such as a service which would match customer interest profiles with knowledge profiles of contract consultants in other countries, permitting rapid question and answer exchanges on a fee-for-service basis, with the "matchmaking" service retaining a percentage of the consultant's fee.

Of these four items, the first three are already under consideration by the nascent Pan Pacific Community Association, which might well be an appropriate umbrella organization for such services.

As to domestic services, the Japanese example may again be a useful guide.

After the second network development phase mentioned above, creation of new services seems to arrive at a takeoff point, with many new kinds of services becoming both possible and attractive during a third phase, such as: motor vehicle registration and inspection, nationwide interbank data communication, nationwide cash dispensing, automated meteorological data acquisition, agricultural information distribution, emergency hospital information, en-route radar data processing, shared-use banking systems, and air cargo clearance, plus touch-tone access. In Japan, this third phase occupied again about five years, although in other countries it could well take much longer.

In a fourth phase of indeterminate length, still further and more difficult applications may be developed: shared-use hospital systems, video response home information, medical treatment information, telemetering, and on-line government record-keeping (welfare, unemployment insurance, etc.).

6.2 MARKET ENHANCEMENT

Figure 3 deals with another long-term strategy which I believe is extremely important, namely, deliberate market enhancement through education of future users and sponsors of data communication services in the region. This is a feedback system in the sense that knowledgeable in-country enthusiasts can help with institutional arrangements for further market enhancement efforts.

7. CONCLUSIONS

Although many of the forecasts and suggestions presented here must be considered preliminary and somewhat hypothetical, there can be little doubt about the central idea--that the growth of new network-based information services in Asia and the Pacific will have to overcome a variety of difficulties related to the region's present economic development level, but if these difficulties can be overcome, such services may in turn offer a significant contribution to the region's economic development process in the future.

NOTES

(1) Kleinjans, Everett, "Crossroads in Communication," Keynote address delivered at the opening session of the First General Assembly of the Asian Mass Communication Research and Information Centre, Singapore, Dec. 2, 1971.

(2) Woods, John L., Utilising Communication to Support Development, Working Paper #327, UNDP Asia and Pacific Programme for Development Training and Communication Planning, Bangkok (Mar. 1976).

(3) Jackson, Peter E., "Services and Architecture for Network Information Systems," Data Communication and Computer Networks: Symposium Record, Networks 80 (Bombay: Computer Society of India, 1980).

(4) Narasimhan, R., remarks at Networks 80 symposium, February 4, 1980, Bombay, India.

(5) Dobrov, G.M., R.H. Randolph, and W.D. Rauch, "Information Networks for International Team Research," Telecommunications Policy, Vol. 2, No. 4 (Dec. 1978), pp. 282-97.

(6) Randolph, Robert H., "Research Cooperation through Digital Networks: Options and Problems in the Pacific Region," Pacific Telecommunications Conference: Papers and Proceedings of a Conference Held January 7-9, 1980... (Honolulu: "Pacific Telecommunications Conference '80," 1980).

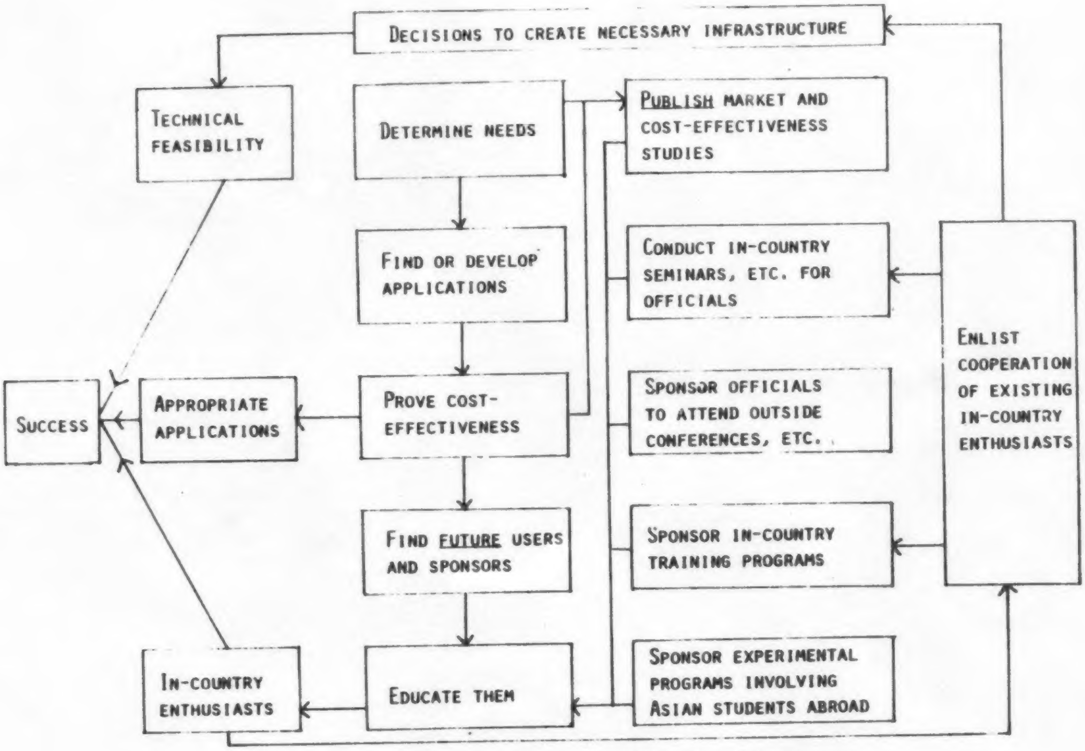
Decisions to create necessary infrastructure
Technical feasibility
Determine needs
Publish market and cost-effectiveness studies
Find or develop applications
Conduct in-country seminars, etc. for officials
Enlist cooperation of existing in-country enthusiasts
Success
Appropriate applications
Prove cost-effectiveness
Sponsor officials to attend outside conferences, etc.
Find future users and sponsors
Sponsor in-country training programs
In-country enthusiasts
Educate them
Sponsor experimental programs involving Asian students abroad

FIGURE 3. LONG-TERM STRATEGY: MARKET ENHANCEMENT

Integration of Computer and Facsimile Communication Services in a Public Packet Switched Data Network

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Abstact

This paper discusses an approach of integrating data and facsimile services in a public packet switched data network. Integration is achieved by advanced communication processing functions provided by networks. Facilities to be implemened include packet switching node, interfacing, interworking, store-and-forward and conversion functions. The experimental packet switched computer and facsimile communication system was constructed to examine the concept.

1. Introduction

Many countries are planning to estabilish public data networks mostly using packet switching technique.

The basic service provided by the public packet switched network is the transport service. The characterics of a virtual circuit is defined by CCITT Recommendation X.25, however, there is a growing demand for new services.

These new services could be regarded as one of the public data network applications.

Therefore, it is necessary to solve the technical problems of the specification, design and development of new services and facilities.

In addition, users are faced with increasing problems of exchanging information between dissimilar sources or devices. The sources differ in format, codes used, transmission speeds, type of information, etc.

In this paper, one approach of integrating dissimilar services in a public packet switched data network is discussed. The design concept was verified by the experiment of computer and facsimile communication through the international public packet switched network.

2. New Services in Public Data Networks

This section will consider implementation possibilities for new services in public data networks. The main service provided by public data networks is the transport data transmission service for computers and terminals.

New type of services such as facsimile, teletex and videotex are being studied by the CCITT. These services have been designed to permit interfacing to the data networks. The benefits to the users are improved performance and reliability in addition to advanced services. The more sophisticated service such as teleconferencing, digital voice transmission using vocoder and electronic mail service may come into service via public data networks in the near future.

Since the most countries employ packet switching technique for public data network, the most efficient solution from the economic and technical point of view is to use packet network to meet the user's requirements. The integration of new services in packet switched data network may be advantageous in terms of facilities sharing and flexibility.

Although the public packet swithced network provides packet level protocol and PAD protocols, there is a need for higher level protocols for meaningful communications between terminals.

Fig. 1 shows the one approach of integrating dissimilar information in a packet switched data network.

The new services or applications adopt end-to-end procedures above transport network layer. End-to-end procedures do not take into consideration the transport and network procedures. A basic model looks like the Fig. 2. An application session is initiated by a certain choice of service. At first virtual call is requested from calling DTE. Then the subscriber establishes the connection to the service. Finally, the subscriber have a number of sessions with various applications.

It is effective that end-to-end procedures to be used within different services have common functions as many as possible. To be connected to the international service, the terminal must accept the basic service characteristics.

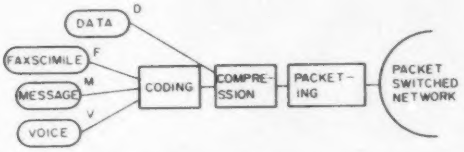

DATA
D
FAXSCIMILE
F
MESSAGE
M
VOICE
V
CODING
COMPRE-SSION
PACKET-ING
PACKET SWITCHED NETWORK

Fig. 1 Integration of Dissimilar Information in a Packet Switched Network

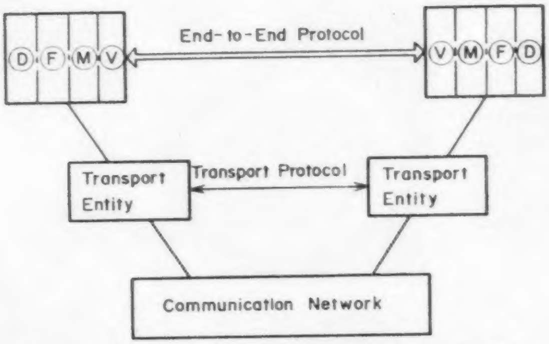

D
F
M
V
End-to-End Protocol
V
M
F
D
Transport Entity
Transport Protocol
Transport Entity
Communication Network

Fig. 2 Basic Model of End-to End Procedure for New Services

3. System Configuration of Integrated Communication Network Services

Apart from the switching node of communications network, the special facilities are required in the network for Integrated Communication Network Services(ICNS). Integrated service system uses the same network components for all types of services.

Fig. 3 illustrates the system configuration of Integrated communication network services using a public packet switched data network.

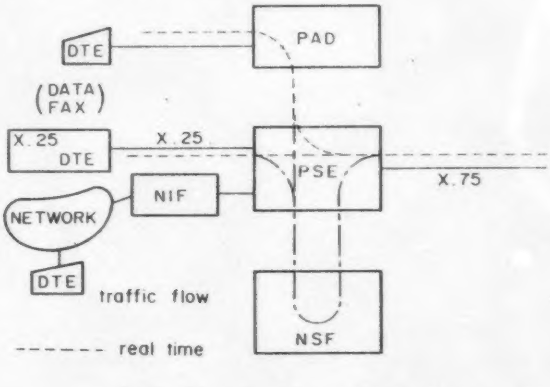

DTE
PAD
(DATA FAX)
X.25 DTE
X.25
PSE
X.75
NIF
NETWORK
DTE
traffic flow
NSF
real time
S/F

Fig. 3 System Configuration for Communication Network Services

Standard packet mode terminals are directly connected to packet switching node, while messages from non standard terminals are entered or accessed through universal PAD using an appropriate terminal for message involved. The access path between the terminal and the universal PAD may be via public switched telephone network or via leased line. Messages are converted to standard packet format, and delivered to packet switching node. If the messages require the additional network services, they are routed to the network service facilities (NSF) for storage before being transmitted to remote sites. The interworking among different network is achieved by intoroducing the network interworking facility (NIF).

3.1 Network access functions for public packet switched network

Users may wish to use TSS or access to the data base available on Host computers connected to public packet switched networks.

CCITT PAD provides protocols for start-stop mode terminals to communicate with X.25 Host computers. In addition to PAD function, a more advanced form of protocols such as virtual terminal protocol will enable the network to accomodate an increasing variety of data terminals.

Another types of PAD which is specifically designed for other services like facsimile may be used for packet network. Network access facilities perform real time protocol conversion, and need a limitted size of buffer memory for processing. Another function is that of a cluster controller or terminal concentrator (TC) to public packet switched network.

3.2 S/F functions provided by Network Service Facilities

In order to provide higher level network services, it is necessary to install the store-and-forword message processing functions in packet switched data networks. These functions should be provided by additional facilities in addition to the basic service. It seems to be reasonable to install an independent equipment from the packet switching node, because the store-and-forward functions need a large size of memory and processing functions. Storage services like Mail Box, Delayed Delivery or Multi-address Calling can be classified to this case. Message to message conversion is also provided using this facility.
The provision of such additional facilities requires the protocol between terminal and store-and-forward facility.

3.3 Network Interworking Facilities

As public data networks are becoming available, interconnecting these networks with existing networks is important. The interfaces between the networks have to support global addressing and internetworking routing for the process to process communication.
Protocol mapping and protocol conversion have to be supported by network interworking facilities. The protocol conversion is used where protocols of the same service level have to be transformed because of their imcompatible formats and differences in some of their functions.

Network interworking technology may be classified to (a) Call featured interworking and (b) Message featured interworking. In the call featured interworking, a call stays through the two network. If a link (or virtual link) is cleared in either network, the interworking does not continue any more. The CCITT recommendations X.3, X.28 and X.29 may be an example of the call featured interworking.
In the other case, message featured interworking, the interworking is realized by more than one call, where these calls do not exist at a same time : generally, after one DTE has finished necessary information transfer to a storage node, another call is established between the storage node and a DTE in the other network. A message featured interworking allows the user to send and receive messages using the storage resources of the network.

3.4 Network Independent Interface

When there exist plural number of networks applicable to data and facsimile communications (e.g. public switched telephone network, packet switched data network, circuit switched data network, leased lines,...), subscribers are obliged to have extra DTEs to communicate with more DTEs at the remote location. Network independent interface is effective for the subscribers not to pay for the extra DTEs and access lines.

3.5. Interworking and compatibility with other services

There are many possiblities for service interworking, e.g., a teletex terminal might have access to the videotex service to seek information from a data base.

It is desirable that masseges from a teletex terminal are delivered to a facsimile terminal. From a country having only a telex service, a user might wish to send messages to a user of the teletex service in another country.
It is likely that these different types of interworking may pass through international transit centers where interworking facility should be attached. Service interworking identifier will be required when communicating with an interworking facility.
Fig. 4 shows the network configuration of the public packet swithced network and the related facilities.

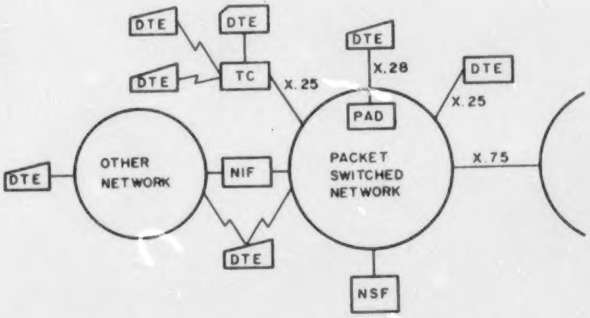

DTE
DTE
DTE
TC
X.25
DTE
X.28
PAD
DTE
X.25
X.75
DTE
OTHER NETWORK
NIF
PACKET SWITCHED NETWORK
DTE
NSF

Fig. 4 Configuration of Networks and Facilities

3.6 User Information provided by Network Service Facility

Network Service Facility can provide facilities for information delivery and collection. Directories and operating instructions may be included in a Network Service Facility as a free information service.
Directory information may contain:

- address of first or exact designation;
- in terms of characteristics specified;
- the type of connection of the terminal

4. Experimental Computer and Facsimile Communications system through Public Packet Switched Networks

In order to put our ideas into practice, we have constructed the experimental packet switched computer and facsimile communication system as shown in Fig. 5, and carried out the experiments through an international public packet switching network between Japan and foreign countries. The system provides a valuable results for integrating computer and facsimile services in a public data network.

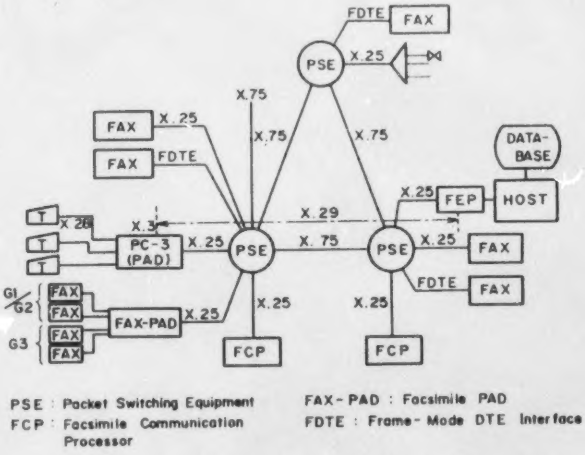

FDTE
FAX
PSE
X.25
X.75
FAX
X.25
FAX
FDTE
X.75
X.75
DATA-BASE
HOST
FEP
X.25
X.29
X.3
T
X.28
T
T
PC-3 (PAD)
X.25
PSE
X.75
PSE
X.25
FAX
FDTE
FAX
G1/G2
FAX
FAX
G3
FAX
FAX
FAX-PAD
X.25
X.25
X.25
FCP
FCP
PSE : Packet Switching Equipment
FCP : Facsimile Communication Processor
FAX-PAD : Facsimile PAD
FDTE : Frame-Mode DTE Interface

Fig. 5 Experimental Packet Switched Computer and Facsimile Communication System

4.1. Interactive Computer Communication Service through a Packet Switched Network

As a realization of the interactive communication service through a packet switched network, we have constructed the protocol converter PC-3 (PAD) in the experimental system. In order to provide a reasonable and flexible service, we have to sopport several types of terminal over public packet network. The protocol converter complies with the CCITT Recommendations X.3, X.28 and X.29 and are applied for the connections of asynchronous terminals. (1), (2)
Software implementations are layered and modular structures, and easy to endure future extensions and improvements.

The experiment of the TSS and data base access to overseas Host via VENUS node using the CCITT PAD protocols was performed successfully. Fig.6 shows the format of Call Request Packet which was used for test of international virtual circuit connection. DTE address based on X.121

is shown in Fig.7

Sequence diagram for databace access using PAD protocol is shown in Fig.8. This protocol supports end-to-end communication and coordination which means estabilishment and termination of logical channel and an active session. In addition, the host computer in Japan (KDD Laboratories) which provides TSS supportiong X.25 and X.29 protocols was tested for international connection.

Operationally, the customer inputs the calling and called DTE address which are carried by CR (Call Request) packet. In case of dial up connection, the customer first dials the assigned telephone access number and sends service request signal to PAD which in turn request the customer's terminal to give its DTE address and Username. Then the virtual call is established between calling and called DTEs. After the host computer accepts the call, it sets and reads the PAD parameters by sending set and read parameters PAD message to the PAD. The host computer expects the parameter indication PAD message from the PAD in response to the previous set and read PAD message. Then the host requests the terminal to enter its Password to confirm the validity. Once the "logging in" procedure had been correctly completed, the connection was extended to the host computer or data base. At the end of the call, the customer "logs out" of the network and terminates the connection.

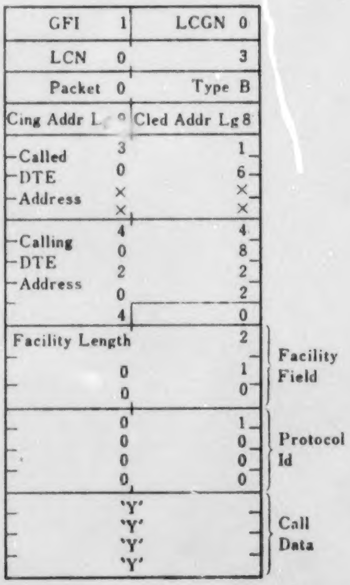
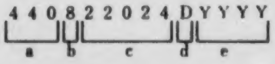

GFI 1
LCGN 0
LCN 0
3
Packet 0
Type B
Cing Addr L 9
Cled Addr Lg 8
Called
DTE
Address
3 1
0 6
× ×
× ×
Calling
DTE
Address
4 4
0 8
2 2
0 2
4 0
Facility Length
2
0 1
0 0
Facility
Field
0 1
0 0
0 0
0 0
Protocol
Id
'Y'
'Y'
'Y'
'Y'
Call
Data

Fig. 6 Format of Call Request Packet


4 4 0 8 2 2 0 2 4 D Y Y Y Y
a
b
c
d
e

a : Data Country Code (DCC)
b : Network Code
c : Individual DTE Address
d : Separator
e : Name of HOST etc.

DNIC

Fig. 7 Example of DTE Addressing

As a realization of an user information service provided by the Network Service Center (NSC), the prototype of network directories service system based on the relational model was implemented using PASCAL. The system supports the SEQUEL language for end users who can make query concerning the data network DTE address etc.

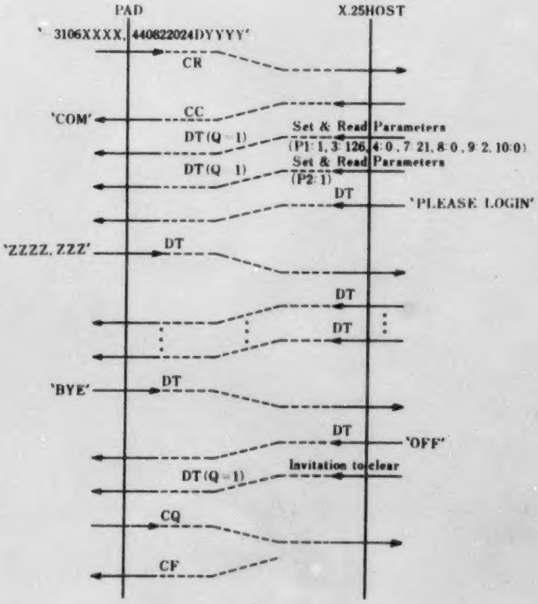

PAD
X.25HOST
'3106XXXX, 440822024DYYYY'
CR
'COM'
CC
DT(Q=1)
Set & Read Parameters
(P1: 1, 3: 126, 4: 0, 7: 21, 8: 0, 9: 2, 10:0)
DT(Q=1)
Set & Read Parameters
(P2: 1)
DT
'PLEASE LOGIN'
'ZZZZ, ZZZ'
DT
DT
DT
'BYE'
DT
DT
'OFF'
Invitation to clear
DT(Q=1)
CQ
CF

Fig. 8 Sequence Diagram of PAD Protocols

4.2. Terminal-to-terminal text communication through a packet switched network

In terminal-to-terminal communication, compatibility problem is very important. One way of overcoming incompatibilities is to define standard terminals. A second technique is to define a Virtual terminal. A third one is the direct conversion between incompatible systems. The necessary protocol and code conversion must be performed in order that dissimilar terminals may communicate with each other. This requires that the network have the knowledge of the code and protocols used, the protocol for negotiating compatibility.

Message communication system between end users via a public packet network has been designed and implemented using PAD-PAD protocol and virtual terminal protocol. In the virtual terminal case, communicating word processors and data terminals were connected to packet switched network using X.25 as shown in Fig.9. The primary terminals are used for negotiation before the real message communcation begins.

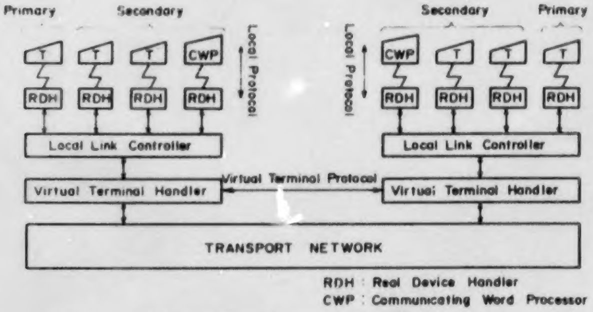


Fig. 9 Terminal-to-Terminal Communication based on Virtual Terminal Protocol

6.3. Facsimile Communication system for Packet Switched Network

In a packet switched data network, facsimile information can be manipulated in the same way as data. Therefore, high speed facsimile message transmission, good quality of received copies, and provision of various kinds of store-and-forword services are easily attained for users. We have developed the experimental facsimile communication system using packet switched network, and carried out the field trial via international packet network. (3), (4), (5)

(1) Digital Facsimile Equipment for the Packet Switched Data Network

Digital facsimile equipment for the packet switched data network can transmit documents fastly without transmission errors. Two-way simultaneous transmission between two facsimile equipments is possible by X.25 or Frame-mode DTE interface. In addition, the facsimile equipment can simultaneously transmit and receive documents to and from another equipment using multi channels of X.25 interface. Moreover the facsimile equipment can request the store-and-forward services provided by FCP.

(2) Facsimile Communication Processor: FCP

For the purpose of providing various kinds of store-and-forward services peculiar to facsimile communcation and facsimile terminal profile conversion service, we have developed a Facsimile Communication Processor FCP which includes a minicomputer with disk storage. The facsimile data encoded by Modified READ code is transmitted and stored in FCP. Facilities provided by FCP are multi-address delivery, delayed delivery, mail box and terminal profile conversion. An example of protocol between facsimile terminal (FAX) and FCP is shown in Fig. 10 for delayed delivery service.

If FCP can not deliver the stored message, the calling terminal receives automatically the notification message of delivery failure in the form of facsimile message in case of multi-address delivery or delayed delivery service. FCP can also reply the results of delivery at any time by request. Wherever user data is stored in the network as a mailbox service, password is used to control access to such data.

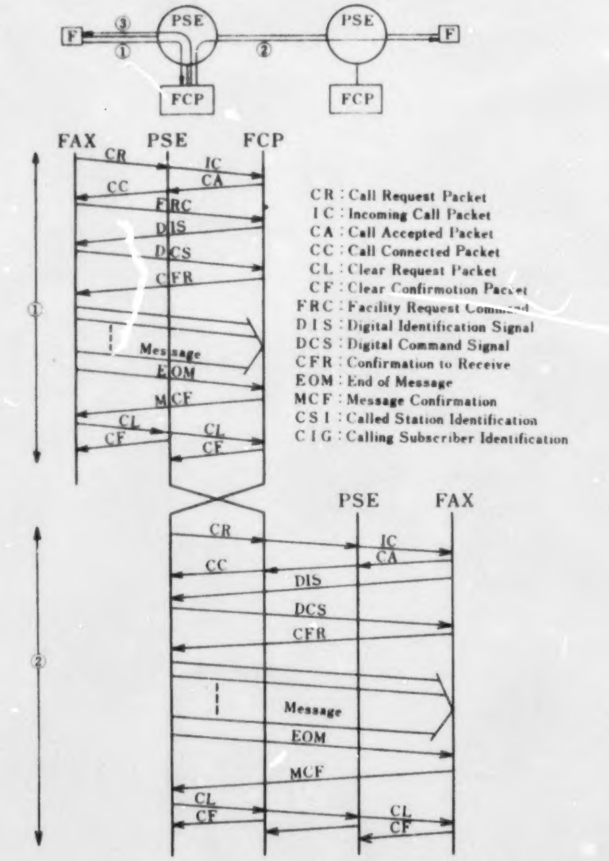

F
③
PSE
①
②
PSE
F
FCP
FCP
FAX
PSE
FCP
CR
IC
CA
CC
FRC
DIS
DCS
CFR
①
Message
EOM
MCF
CL
CF
CL
CF
PSE
FAX
CR
IC
CA
CC
DIS
DCS
CFR
②
Message
EOM
MCF
CL
CF
CL
CF
CR : Call Request Packet
IC : Incoming Call Packet
CA : Call Accepted Packet
CC : Call Connected Packet
CL : Clear Request Packet
CF : Clear Confirmotion Packet
FRC : Facility Request Command
DIS : Digital Identification Signal
DCS : Digital Command Signal
CFR : Confirmation to Receive
EOM : End of Message
MCF : Message Confirmation
CSI : Called Station Identification
CIG : Calling Subscriber Identification

Fig. 10 Sequence Diagram of Delayed Delivery Service

(3) Facsimile Packet Assemble and Disassemble Equipment: FAX-PAD

It is very important to realize the mutual communication between G4 facsimile equipment on Public Data Network and G1, G2, G3 facsimile equipment on General Switched Telephone Network. This was accomplished by putting a FAX-PAD between the GSTN and Packet Switched Network. The G1, G2, G3 facsimile equipment are connected, via FAX-PAD, to public packet switched network. FAX-PAD performs the facsimile signal conversion, protocol coversion, etc. System conversion within FAX-PAD is performed line by line on real time basis. Table 1 shows the facsimile conversion in FAX-PAD.

(4) Results of experiments

We have performed the end to end facsimile communication using international packet swiched networks. There was no significant degrade of throughput of document transmission if we chose the proper system parameter such as window size W or maximam outstanding frames K. The functions of the interface and end to end protocol performed well.

Table 1. Facsimile conversion in FAX-PAD

Conversion	GSTN (G1, G2, G3)	PSDN (G4)
Facsimile message	G1, G2; analogue signal G3 : MH or MR (K=2,4)	MR (K=∞)
Message transmisson speed	G1 : analogue signal (6 min/page) G2 : analogue signal (3 min/page) G3 : 4800 bps (9600 bps)	48 Kbps
Protocol	G1, G2; T.30 (tonal signalling) G3; T.30 (binary coded signalling)	X.25 (level 2 and level 3) extended T.30 (level 4)
Protocol signalling rate	G1, G2: tonal signalling G4 : 300 bps	48 Kbps

5. Conclusion

The discussions above have shown that the most new services could utilize a public packet switched data network, requiring only certain additional facilities. Network access facilities, interworking facilities and message handling facilities in packet switched data networks will accommodate the integration of variety of information sources in public data networks, and provide new services and applications for network users.

There is an important difference between the facsimile and text messages. Textual messages are coded information and usually small, whereas the facsimile data is non-coded information and much larger. Hence all the facsimile information through a packet switched network was coded by Modified READ code with optimum data compression, the public packet network can handle all the information in a same way.

The introduction of integrated message service on public data network will require standardization on universal PAD facilities and message handling facilites. Preliminary system concepts and operational procedures for new services such as interactive communication service and facsimile was examined by the international experiment of computer and facsimile communication via public packet switched network.

KDD is introducing a new public packet switched network service under the VENUS project. The ideas introduced in this paper and results of the experiment will be effectively used for the VENUS project.

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On the Selection of Optimal Paths Which Satisfy Additional Constraints

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Abstract

The problem of selecting an optimal path for each pair of nodes in a communications network for any given optimality criterion is considered. The additional conditions that the set of selected optimal paths must satisfy are 1). each path is physically reversible, and 2). a single path identifier is sifficient to create routing tables for those selected paths. Another problem considered is the selection of remaining paths which satisfy the above conditions when paths are pre-selected or hand-picked for some pairs of nodes. Solution for each of these problems is presented. All the algorithms described have been coded in PL/1 and run successfully.

1. INTRODUCTION

In this paper, we consider the following optimal path selection problem which arises when one considers defining routing tables for SNA(3).

> For a given optimal path criterion, select a single optimal path for each pair of nodes such that the following two conditions are satisfied by the selected paths:
> (C1). each path is physically reversible, and
> (C2). a single path number (or identifier) is sufficient to create routing tables for all those selected paths.

In SNA(3), an explicit path routing is used for message transmission from an origin node to a destination node. A network operator is allowed to define multiple (up to 8) communication paths (called explicit paths or routes) between each pair of nodes. An explicit path is an ordered sequence of nodes and links in a network. In SNA, it is required that each explicit path defined in routing tables must be physically reversible, otherwise the path will never be used for communication. An explicit path (or path for simplicity) from node a to node b is said to be physically reversible if its reverse path from node b to node a is also defined in the routing tables. An explicit path may be considered as a set of links in a network if each link in the network is uniquely identifiable.

The second condition (C2) is not a requirement in SNA, but rather an additional constraint we impose on the selected paths to simplify the path numbering problem which arises when one creates routing tables for SNA networks. A routing table consists of routing entries each of which consists of three fields: destination node (DN) field, path number (PN) field, and the field which indicates the outgoing link queue leading to the next node (NN). Each message header contains, among others, its destination and the selected path number at its origin node. When a message is received at an intermediate node, the intermediate node finds a routing entry which corresponds to the destination and the path number stored in the message header. Then, the message is sent to the appropriate outgoing link queue for transmission. This is depicted in Fig. 1.

The path number (PN) stored in a message header is used to select an appropriate path from an intermediaten node to the message destination node since multiple paths may exist from the intermediate node to the destination node.

In SNA, when a path number is assigned to a path, all path segments from intermediate nodes to the destination node that comprise the original path must be assigned the same path number.

In constructing such SNA routing tables, one may first select multiple paths for each pair of nodes (6), and then assign minimum number of path numbers to the selected paths by avoiding numbering conflicts. This number assignment often requires more path numbers than the number of paths being defined in the routing tables for a pair of nodes, and the optimal assignment of path numbers to the selected paths is an NP-complete problem (4). One way to avoid such a general assignment problem is for the selected paths to satisfy the condition (C2).

2. PROPERTIES

In this section, we discuss some properties associated with the path selection problem described in the previous section. These properties will lead us to solutions of the problem. In the following, the SNA routing tables described in the previous section will be referred to as the routing tables without confusing with other types of routing tables.

Theorem 1.
Paths (one path for each pair of nodes in a network) selected for all pairs of nodes in a network can be defined in the routing tables using a single path number iff for each destination node, the collection of paths to the destination node forms a tree.

Proof:
For the necessary condition, let's assume that the entire collection of paths can be defined in the routing tables using a single path number but a collection of paths to a particular destination node does not form a tree. This implies that there exists a node i in the collection of paths to the destination node d such that node i has more than one outgoing link to the destination node d. Since the message routing at node i is performed using the destination node and the path number stored in a message header, it requires more than one path number to distinguish paths from node i to the destination node, which is a contradiction.

For the sufficient condition, let a set of paths to a destination node forms a tree and thus any node i in the tree has a single outgoing link which leads to the destination node d. This implies that node i supports only a single path to the destination node, which requires a single path number. (QED)

Theorem 1 allows us to replace the condition (C2) of our path selection problem by the following tree condition (C2'):

(C2'). A collection of paths to each destination node forms a tree.

Theorem 2.
A collection of paths to a destination node d forms a tree iff a path from node a to node d, $p(a,d)$, contains the path from node i to node d, $p(i,d)$, for every node i which appears in $p(a,d)$ as an intermediate node for every node a.

Proof:
For the necessary condition, let's assume that a path $p(a,d)$ contains a node i but the path $p(i,d)$ is not contained in $p(a,d)$. Then, node i must support two path segments (or two outgoing links) to the destination node d. Thus, the collection of paths to the destination node d does not form a tree, which is a contradiction.

For the sufficient condition, assume a set of paths to a destination node does not form a tree. Then, there exist a node a and node i in the collection such that the path $p(a,d)$ contains node i but $p(a,d)$ does not contain the path $p(i,d)$. (QED)

Theorem 2 implies that the tree condition (C2') can be satisfied by enforcing the path containment property to each destination node.

3. PATH CHARACTERISTICS

Each communication path in a network offers, in general, different path characteristics. Some of these characteristics are path length (number of links in a path), delay, capacity (or speed), availability (the probability that a path is connected), and quality (one minus error rate in probability). Because of these variety of characteristics, one must define exactly what optimality criterion should be used for 'optimal' path selection.

We assume a function f for an optimal path selection. Let's consider two communication paths p1 and p2. Let's also assume that path p1 is better than path p2 with respect to a given optimality criterion f, i.e., path p1 is closer to an optimal path than path p2 does with respect to f. We denote this condition by the following notation:

$$p1 >f p2.$$

Furthermore, $p1 =f p2$ means that p1 and p2 are equally good with respect to f. We also limit ourselves to only those criteria f which satisfy the following conditions:

(C3). If $p1 = p2$ then $p1 =f p2$.
(C4). $p1 >f (p1 \cup p2)$.
(C5). If $p1 >f p2$ then $(p1 \cup p3) >f (p2 \cup p3)$ for any p3.
(C6). If $p1 >f p2$ then $p11 >f p22$ for p11 and p22 such that $p1 = (p11 \cup p12)$, $(p11 \cap p12) = \emptyset$, $p2 = (p22 \cup p12)$ and $(p22 \cap p12) = \emptyset$.
(C7). For given p1, p2 and p3, if $p1 >f p2$ and $p2 >f p3$ then $p1 >f p3$.

4. ALGORITHMS

There are quite a few shortest path algorithms available in literature (5). Two of the most well known shortest path algorithms are the Floyd algorithm (2) and the Dijkstra algorithm (1). Both are of $O(n^3)$ in computational complexity, where n denotes the number of nodes in a network. In the following, we first generalize these two algorithms for any given optimal path criterion f discussed in the previous section.

Algorithm GF (Generalized Floyd algorithm)

```
1.  Let $p(i,j)$ = direct link from node i
    to node j.
2.  Set $i = 1$.
3.  For all $j (j \neq i)$ and for all $k (k \neq j,i)$
    if $p(j,k) <f (p(j,i) \cup p(i,k))$ then
    p(j,k) = (p(j,i) ∪ p(i,k)).
4.  Set i = i + 1.
5.  If i ≤ n then go to 3, otherwise
    stop.
```

In Algorithm GF, if $p(i,j)$ is the reverse of $p(j,i)$ and $p(i,j) = p(j,i)$ for every i and j in step 1, the reversibility condition (C1) hoids for the resulting paths. However, the paths given by the algorithm does not, in general, satisfy the tree condition (C2') since an optimal path between a pair of nodes is not necessarily unique.

Algorithm GD (Generalized Dijkstra algorithm)

```
1. Set d = 1, and set tree T(d) = {d}.
2. Find j such that p(d,j) is the best
   among j ∉ T(d)
      with respect to the given
   optimality criterion f.
      Include node j in tree T(d).
3. If any node in the network is not
   contained in T(d), go to 2.
4. Set d = d + 1.
5. If d ≤ n then go to 2, otherwise stop.
```

The Dijkstra aigorithm does not, in general, give optimal paths for the network with negative edge/link weights. However, such case is excluded from our consideration by the condition (C4). Because of the nature of Algorithm GD, which keeps a tree for each destination node d, the resulting paths satisfy the tree condition (C2'). However, the resulting paths may not be physically reversible since an optimal path between a pair of nodes may not be unique. After the termination of Algorithm GD, one may set $p(i,j)$ to be the reverse of $p(j,i)$ for all i and j. However, the resulting paths may no longer satisfy the tree condition (C2').

We have thus far described two possible algorithms one may use for the selection of optimal reversible paths for all pairs of nodes in a network. In these algorithms, we used the notation $p(i,j)$ to denote an explicit path from node i to node j. However, in actual implementation of these algorithms, one may not evaluate or store $p(i,j)$ explicitly at each intermediate step.

We next describe an algorithm, which we call Algorithm T, which can be used to select paths satisfying the tree condition (C2') when optimal paths (physically reversible or not) are presented to the algorithm. This algorithm enforces the path containment to meet the tree condition (C2') of Theorem 2.

Algorithm T (path tree algorithm)

```
Let p(i,j) be an optimal path from node i
   to node j.
1. Set i = 1.
2. For all j (j≠i) and for all k (k≠j,i),
      if p(j,k) =f (p(j,i) ∪ p(i,k)) and if
      node i is on path p(j,k), then set
      p(j,k) = (p(j,i) ∪ p(i,k)).
3. Set i = i + 1.
4. If i<n then go to 2, oterwise stop.
```

Theorem 3.
Algorithm T gives optimal paths which satisfy the tree condition (C2'). If paths given to the algorithm are physically reversible, then the resulting paths are also physically reversible.

Proof:
Let T be a collection of paths rooted at node k which contains all optimal paths to the destination node k in that any identical path segments to k are merged. Thus, T is a tree in which some node may appear more than once. Let T(s) be such a tree resulting from applying i = 1 through s in the algorithm.

We will show that in T(s), each of nodes 1, 2, ..., s appears exactly once, i.e., application of i = s to T(s-1) results T(s) in which node s appears exactly once.

In T(0), each node, except k, may appear more than once. Application of step 2 for i = 1 results in the following replacement. If a path from node j to node k contains node 1 as an intermediate node, the path segment from node 1 to node k in that path will be replaced by the optimal path from node 1 to node k for all j. Since every path segment from node i to node j becomes the same as the path from node i to node k, and the path from node i to node k is optimal (loopfree), the node 1 appears exactly once in the resulting T(0).

Let us assume that in T(s-1), each node 1, 2, ..., s-1, appears exactly once. We next show that the application of step 2 of Algorithm T for i = s results a tree T(s) in which each of nodes 1, 2, ..., s-1, s, appears exactly once. It is clear that because of replacement for i = s, node s appears exactly once in T(s). Thus, we show that each of nodes 1, 2, ..., s-1, appears exactly once after the path replacement even though some of 1, 2, ..., s-1, may appear in the optimal path from node s to node k.

Without loss of generality, let node t, $t < s$, appears in the path from node s to node k. If no such node t exists, then the proof is complete. Since $t < s$, in T(s-1), the node t apperas exactly once. Thus, the replacement by the optimal path from node s to node k does not increase the number of appearances of node t. This will complete the proof of the first half of the theorem.

When paths given to the algorithm are physically reversible, the physical reversibility on paths for each i is enforced by the operation $p(j,k) = (p(j,i) \cup p(i,k))$ since $p(j,k) =f (p(j,i) \cup p(i,k)) =f (p(k,i) \cup p(i,j)) =f p(k,j)$ holds. (QED)

We are now ready to present a solution to our problem of finding an optimal path for each pair of nodes such that each path is physically reversible and a collection of paths to each destination node forms a tree. Other solutions may be found in (7).

Algorithm 1

1. (Derive a "simple" network) If more than one link exists between a pair of nodes, select just one link bv applying a given optinality criterion f.
2. (Select optimal reversible paths) Run Algorithm GF or run Algorithm GD and then set p(i,j) to be the reverse of p(j,i) for all i and j.
3. (Enforce the tree condition) Run Algorithm T.

5. ADDITIONAL REQUIREMENT

In practice, there exists a situation that some desirable paths are 'hand-picked' or 'pre-selected'. The problem then is to select the remaining paths such that those paths selected by the algorithm and those hand-picked paths satisfy the reversibility condition (C1) and the tree condition (C2'). Here we assume that the hand-picked paths are reversible and the collection of hand-picked paths for each destination node forms a tree.

A solution to this problem which will be described next is based on pre-processing a given network in such a way that algorithm is forced to pick the hand-picked paths whether or not the hand-picked paths are optimal with respect to a given optimal criterion f.

Algorithm 2

1. If more than one link exists between a pair of nodes, select one link by applying a given optimality criterion f and derive a simple network.
2. (Select optimal paths) For each destination node k, repeat the following steps:
   - 2.1. From a simple network, construct a directed graph by replacing each undirected link by two directed arcs.
   - 2.2. Imbed each hand-picked path to destination node k into the directed graph in the following manner: let for convenience, a hand-picked path to a destination node k is denoted by n1 -> n2 -> . . nj -> . . -> nk, where nk = k. From the graph, delete all outgoing arcs from nodes n1,n2,...,nk. Then insert an arc (nj -> nj+1) at node nj for all j.
   - 2.3. Apply steps 1, 2 and 3 of Algorithm GD for d=k.
3. (Enforce path reversibility) If p(i,j) is not the reverse of p(j,i) then set p(i,j) to be the reverse of p(j,i) for all such i and j.
4. (Enforce the tree condition) Run Algorithm T.

Fig. 2 illustrates a simple example of how to imbed given hand-picked paths into a directed graph. (a) shows a simple 5-node network. (b) shows the corresponding directed graph. Let's consider the destination node E and a hand-picked path of A -> D -> C -> E. From the directed graph of (b), first eliminate every outgoing arc at nodes A, D, C and E. Next, insert arcs (A -> B), (D -> C) and (C -> E). The resulting directed graph is shown in (c).

It is clear that the resulting paths from Algorithm 2 satisfy the reversibility condition (C1) and the tree condition (C2'). As the following theorem shows, Algorithm 2 includes the hand-picked paths.

Theorem 4
Paths given by Algorithm 2 contain all hand-picked paths.

Proof:
It is clear that the collection of paths given at the completion of step 2 contains all of hand-picked paths and are physically reversible. Thus, we must show that Algorithm T will not replace any hand-picked path by some other paths.

In Algorithm T, path replacement occures only when node i appears more than once in the rooted tree T(i-1) to a destination node k (see the proof of Theorem 4). Thus, it is sufficient to show that any node i which appears in a hand-picked path to destination node k does not appear more than once in T(0). This condition, however, is enforced in step 2.2. Furthermore, step 3 is not applicable to any hand-picked path. (QED)

6. SUMMARY

We considered the problem of finding an optimal path for each pair of nodes in a network such that each path is physically reversible and it requires a single path number to define the selected paths in the SNA routing tables. For this problem, we first developed an algorithm. We then generalized the algorithm to incoporate given hand-picked paths for the selection of remaining optimal paths. These algorithms have been coded in PL/1 and run successfully.

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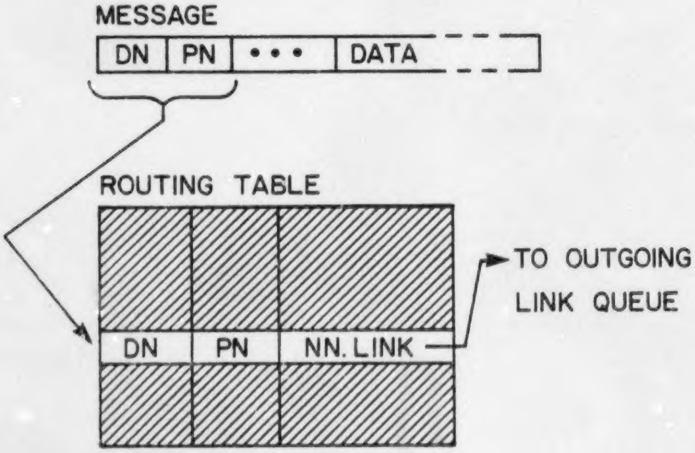

Fig. 1 Explicit Path Routing

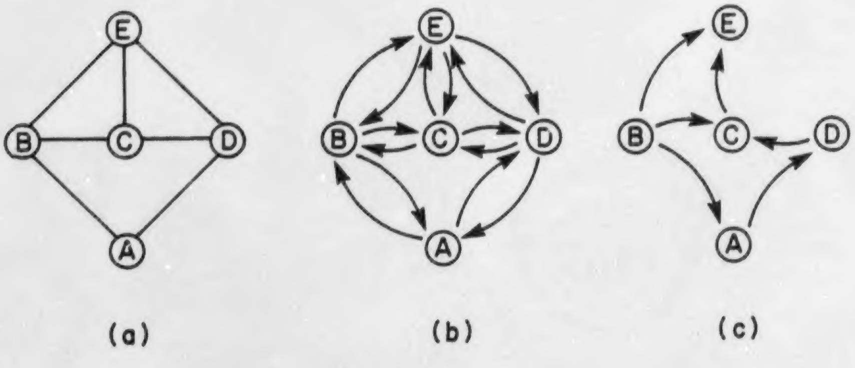

Fig. 2 Imbedding Hand-picked Paths

IMPLEMENTATION OF VOICE AND DATA FEATURES ON DIGITAL EXCHANGES

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Abstract

Extensive network planning studies have been performed on a wide variety of real networks. The results include specific recommendations for those digital introduction (IDN) transition strategies that lead to important long-term economies without the near-term economic or operational penalties that accompany certain strategies; further recommendations cover the second transition toward the handling of data and other non-voice traffic (ISDN) and these include requirements on digital exchange architecture.

INTRODUCTION

Two major technological changes are occurring in the telecommunications field, almost at the same time: the introduction of digital techniques for both transmission and switching, and the accommodation of non-voice services (that is, data) on the previously voice-only telephone network. In many countries these two events follow closely behind the introduction of computer controlled exchanges, SPC exchanges. Considering the previous rather slowly changing technological history of communications, and of telephony in particular, these recent events seem to foretell that the future of telecommunications will be one of continued change in response to the advantages to be obtained from technological innovations and from the new services that can be offered economically using this technology. Coupled with these realizations is the clear fact that the needs of society in terms of information delivery are also changing rapidly and telecommunications networks are the primary means for meeting those needs. As a result of these considerations the traditional role of planning for telephone networks, or more generally for telecommunications systems and their interconnection into networks, has itself changed. Telecommunication planning has been directed toward proposing the most economical and operationally convenient means for providing telephone services for an expanding group of subscribers -- of course with due regard to quality of service and the recent provision of what are termed "SPC" services. Now the task includes planning expansions in terms of the number of subscribers served with both voice and non-voice services, and in assuring that in the future these expansions to the present network will be capable of handling new features and new services as yet undefined today. In a sense this means that forward planning must provide "future safe" designs for both the network and the equipment in the network.

The future development of telephone networks seems to be burdened in the historical direction by the immense capital investment represented by equipment installed in networks throughout the world; and in the forward direction by uncertainty resulting from the tremendous number of options that the new digital technology has produced. How can a telephone administration simultaneously make maximum use of its current investment and introduce a new technology and new services in a way that will neither prejudice future introductions of even newer technology and newer services nor cause a near-term economic penalty in return for that future security guarantee? The solution is to use that new technology itself to design network and equipment structures which meet current requirements more economically than was possible with the previous technology and to design network and equipment structures that will accept new technology (that is, equipment realizations and new functions or new services) without the need for replacements or retrofitting. This new criterion must be added to the planning task and the quality of new designs for networks or for equipment should be judged by this criterion as well as the traditional ones of overall economics, operational convenience, maintenance and quality of service, transmission plan, etc.

Another new aspect of telecommunications network planning concerns the new digital exchange structure. Previously it was sufficient to characterize new exchanges in a network planning exercise by their external features (cost curve, traffic capacity, lines and trunks, extension module size, space and power requirements). If the criterion for future service and technology accommodation is to be met, the digital exchange's architecture becomes an important characteristic; that is, only when the structure of these digital exchanges meets the criterion for convenient and economical acceptance of new technology and future services will the network of these exchanges be capable of such accommodation. Therefore digital exchange architecture now is an important element in network planning, with at least one digital exchange structure, fully distributed control, demonstrating an inherent advantage.

STUDIES OF DIGITAL NETWORKS

There are several different strategies for introducing digital switching and transmission into existing networks. Since the digital introduction process will extend over a 10- to 20-year period in most countries, the need was recognized for a basic understanding of mixed digital and analog networks and an extensive series of network planning studies were performed by ITT's laboratories and manufacturing units to evaluate different digital introduction strategies and also to determine the most suitable characteristics for digital switching and transmission equipment.

While it was clear that digital exchanges, concentrators and transmission equipment could be installed as independent units in an analog environment when they were individually more economic than their analog counterparts, it was found that there are major advantages to the integration of digital switching and transmission, the integrated digital network or IDN approach, making their combined utilization most attractive. The basic questions for the IDN study were: how to integrate digital switching and transmission, what should be the network configurations and what introduction strategies should be employed? Important results were derived from these studies on network configurations and introduction strategies, leading to the overall conclusion that digital introduction presents no special problems in network evolution; and that with proper network planning and a suitable digital switching system, digital introduction into existing networks can be accomplished without large initial expenditures, either for rearrangements or for the large, non-line-related, getting-started costs associated with some equipment configurations and introduction strategies. The major result was that an approach with economic justification at each step ("pragmatic") is usually optimum.

IDN STUDY OBJECTIVES AND METHODS

Initially an implementation or transition strategy is needed: whether to use a strict overlay scheme or a replacement plan or side-by-side placement (both digital and analog units at the same location) or a hybrid arrangement (analog lines and digital trunks). Associated with this strategy is a transition doctrine, or the economic means by which transition is achieved; for example, whether to extend the existing system with the existing technology as opposed to introducing new digital equipment. And, of course, there is the question as to when conversion to digital should begin. With answers to these questions overall network designs can be specified. This is the ultimate, fully digital network, essentially the target toward which the transition scheme is moving. It is important to recognize that this target may not be the digital network that one obtains by optimizing the network in the absence of existing equipment, that is, building the complete network from the beginning, the "green-field" exercise. Instead, for the studies reported here a final network configuration was sought that would result from the least capital and operations expenditure over the long transition time while meeting performance criteria and either demand or capital-expenditure criteria. Having answered these questions, it was then possible to specify an overall system for a digital product series, from remote units through the broad range of local and toll exchanges, and to indicate the units' design characteristics, like performance, modularity, reliability, etc. Indeed the results helped set specifications leading to ITT's System 12 design.

The study method was comparative costing of analog and alternative digital solutions, each fully meeting demand and performance criteria for real, existing networks over a time period by installing either analog switching equipment or digital switching equipment and then comparing the cost consequences of these solutions. Both the analog reference and digital solutions used SPC (stored program controlled) exchanges with both centralized and distributed control. In both the analog and digital cases, PCM transmission was "installed" wherever economic. Price comparisons were made on the basis of first cost summations (equipment and maintenance and operations expenditures cumulatively totaled throughout the study period) and also by PVAC (present value of annual charges) calculations, the latter a superior technique now generally used for economic comparisons including the passage of time.

Since one of this study's objectives was to assist in the design of the digital system itself, variations in the digital system's characteristics were proposed and then used in the planning studies to determine their network application advantages. For example, several remote units were considered, differing in size, cross-point (space or time) and degree of dependency. In a sense the study provided a test-bed for trials of ideas on the design of a digital equipment line (and it will continue to be used for ITT's System 12 in this fashion).

At all times the study took the point of view of a telephone administration determining its course of action for the next 10 to 20 years. Therefore, full consideration was given to existing plant which had to be described in great detail so that the planners would understand situations that could not be handled by solely economic considerations. Also, as much as possible, administration practices were employed. Since 20-year PVAC studies were chosen as the primary costing technique, it was necessary to include the effect on costs of technology changes during the 20-year period. Cost trend factors were introduced into the calculations and these affected different equipment types separately through the study's course.

It was also necessary to define grade-of-service criteria by which to judge the performance of different networks, where performance includes transmission quality, blocking percentages at normal load and overload levels, network reliability, etc. The potential for a distributed network structure thru the use of dependent digital switching units has made network reliability (as seen by a subscriber) a very important performance element. In order to make meaningful economic comparisons each network solution had to meet the grade-of-service criteria in all aspects, including reliability.

The real-site studies required detailed maps of the regions in question, with detailed population distributions at present and forecasted through a 20-year period. Existing plant layouts were needed, including the location and configuration of exchanges, their service areas and trunking patterns. Existing plant consisted of exchanges (detailed by size, age and capacity), buildings (present occupancy and ultimate capacity), transmission routes (detailing cables, their sizes and acceptability for PCM transmission, ducts and their occupancy), and traffic matrices for interexchange traffic plus growth forecasts. To these were added operations rules in use by the administrations whose areas were being studied.

An extended series of detailed network studies were made jointly by administrations with their local ITT companies. This collaboration of administration and manufacturer effort over a wide variety of situations provides substantial confidence on the generality as well as practicality, accuracy and lack of bias of the conclusions.

For each of the studies fully detailed year-by-year network plans for 20 years were designed for both the analog and digital solutions. Different configurations of the digital equipment were proposed and tried so that their comparative economics and flexiblity could be measured. In every case administrations' viewpoints were taken, so that the results would reflect the interests of those administrations. In effect our planners played the roles of administrations in choosing their strategies for the introduction of digital switching and transmission into their networks.

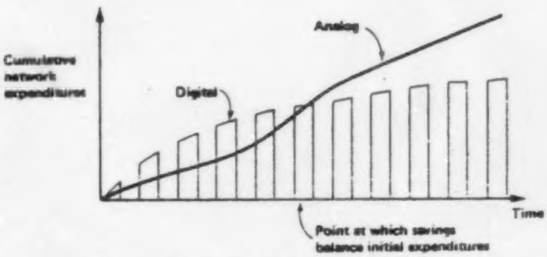
DIGITAL INTRODUCTION RECOMMENDATIONS

After studying the most well known digital introduction strategies and realizing the inherent problems and costs associated with them, the planners found that the most successful strategy was really a pragmatic approach with each step in the network growth economically justified through global network planning studies. The overlay technique, the so-called side-by-side method, a replacement regime -- all of these were less economic than the more flexible, more operationally convenient technique we named PRAGMATIC introduction. For example, in studying the overlay method, an initial question was where should the gateways be located and how many should there be. (Gateways are the points of connection between the existing analog network and the new digital network.) Usually this number is set a priori and tends to be small. But the study showed that in additon to being a vulnerable network structure, overlay was expensive, especially during the initial transition years. Instead the planners treated trunk groups between digital and analog exchanges as any other link, justified or not by their traffic loads and the links' costs, now including the analog to digital conversion cost. This is quite similar to methods for dimensioning high-usage groups in an alternate-routing network. The criterion for digital network planning should not be the minimum number of analog-to-digital conversion units (as has been quite mistakingly quoted in several technical articles), but the minimum network expansion expenditure.

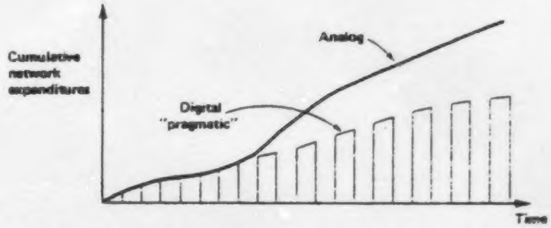
The transition choice -- whether to extend existing exchanges in their own technology or to use remaining building space for digital equipment or to replace the existing unit -- was clearly answered by the pragmatic network planning approach in much the same way as for trunk group justification, namely, examine each case via comparative global economic network studies and make decisions accordingly.

In another area, transit facilities, there is an interesting choice between a purely transit digital exchange and use of the transit capabilities inherent with digital local exchanges, the "distributed tandem concept". Since these local units all have four-wire transmission and there is no essential difference between lines and trunks, the marginal cost for establishing a transit point coincident with a digital local exchange may be far lower than installing a separate transit exchange.

At present and in both analog and digital environments it was also found that a single, large digital exchange could economically replace a number of colocated existing transit exchanges that had previously been handling several different hierarchical levels. Current digital transit exchanges' economy and their large maximum sizes produce this advantageous application. See reference (5).



(a) Digital introduction with major initial expenditures (network rearrangement, overlay, etc.)



(b) Digital introduction with an economically justified or "pragmatic" strategy.

Figure 1. Comparison of the "pragmatic" digital introduction strategy with overlay or others.

The resulting general conclusion is quite important for the introduction of digital techniques in any network, urban or rural, advanced or developing: an economically justified approach is the most economical and the most operationally convenient. This PRAGMATIC approach is superior to all of the doctrinaire and restrictive methods studied. No network rearrangements are required as the network evolves toward digital integration; further, no initial network modification is justified in preparing for digital introduction. Since the period of mixed analog and digital interworking will be several decades long, it is uneconomical to make substantial network rearrangement expenditures now for expected savings 20 years in the future, especially in an era of rapid technological change.

These conclusions are illustrated via the qualitative diagrams in figure 1 that summarize the results from our network studies plus several made by administrations. The near-term differences in expenditures for the two introduction schemes are quite obvious, with restrictive techniques, like overlay, requiring substantial immediate investments that actually raise the digital introduction expenditure curve above the analog curve. Pragmatic (or cost justified) introduction requires no such initial investments and also yields savings years earlier than other methods. The differences in figure 1 for cumulative network expenditures would appear even larger with a PVAC comparison. (Several published papers indicate that an initial penalty is a necessity. Analysis shows that either the planners only considered an overlay or a similar plan, or that their optimization procedure a priori sought to minimize some factor like analog-to-digital conversions rather than overall expenditures.) On a long-term basis, pragmatic and other schemes may tend toward similar cumulative expenditures, but of course not when viewed via PVAC. However, since it is quite certain that the current rate of technological change will preclude following these plans thru the next 20 years, initial penalties associated with restrictive digital introduction schemes will probably never be absorbed.

In both graphs of figure 1 the digital solution becomes more economical than continuing with the analog alternative. Savings in the order of 30% have been forecasted by these studies considering both operational and investment expenditures. What is the source of those savings? The costs projected thru the study periods were affected by technology factors that raised and lowered prices. There was a balance between increases and decreases in equipment costs, with the main source of savings coming not from a markedly lesser basic cost for digital switching and transmission equipment compared with current equivalents, but from the reduction in total equipment installed resulting from the integration of digital switching and transmission. Digital network planning (on a global basis) will be the means by which administrations take full advantage of IDN's savings potential.

These conclusions can be stated rather simply: digital introduction need pose no problem when economically and operationally planned at each step on a global network basis. It must be added that these results are predicated upon using a fully flexible and modern, fully digital switching and transmission system designed to meet the requirements specified in these studies. With a less capable digital system, the full potential of an integrated network will not be achieved and the transition costs will be higher than these studies showed are needed; further, for a less capable system future accommodation of non-voice services may be precluded, as will be discussed later.

DEPENDENT AND INDEPENDENT SWITCHING UNITS

A topic of particular interest in low density areas is the proper design of remoted subscriber switching units. Different units were "designed" for these studies and then "installed" in the planning exercises. Variations included their maximum sizes, cross-points and degrees of local control. In considering differences between slave and independent units full consideration had to be taken of their differing requirements for trunking, since due to the need for equal reliability performance diversely routed cable runs are required for medium and large size dependent units, but not for independent ones. It was also necessary to "charge" a dependent switching point for the extra overhead and call processing supplied by the master exchange. Thus each network planning study was made on a global basis, considering an entire area and comparing master exchanges with dependent units having different levels of dependency to independent large and small exchanges plus rather small concentrators.

The results showed that the new digital technology which works so well with a distributed control structure has markedly altered the economics at the small end of the switching system scale. Indeed, the new low initial cost for digital microprocessor exchanges with distributed control structure makes small independent exchanges less costly than supplying service via dependent units attached to a master. The microprocessor and distributed control architecture have effectively ended the economic life of the medium to large concentrator.

Another advantage of the independent small exchange is its planning flexibility, since it can be placed anywhere and at any time, without requiring the prior establishment of a large master exchange in the area. This can be very important since supplying service to small towns could be delayed for years waiting until a new large master exchange is justified in the area. In some applications the small independent exchange has a network advantage since it can maintain trunk groups in several directions, rather than the single group from a dependent unit to the master. Of course, there still remains a point below which small remote subscriber units are required to supply service economically to rather small clusters of subscribers; this point is currently at a few hundred lines.

IDN CONCLUSIONS

An immediate set of conclusions can be stated before proceeding with extensions of these IDN studies toward ISDN. First there is the result that the pragmatic recommendations presented here for digital introduction into existing networks (the transition to IDN) are correct as the antecedents for the several valid scenarios leading to the handling of voice and non-voice services on the digital network (the transition to ISDN). In fact, the combination of the IDN pragmatic approach and a fully distributed control architecture for digital exchanges will permit telecommunications administrations substantial flexibility in deciding which non-voice services to introduce on their networks, plus where and when (and whether) to introduce them.

Full advantage of the pragmatic introduction scheme (itself characterized as non-restrictive) is best realized with a digital switching system having the fewest application restrictions. For the administration (with inventory, documentation and training expenses) and for the manufacturer as well, a single, fully applicable digital switching system has a great advantage. Advanced digital techniques, economics of microprocessors and VLSI's in general, and substantial progress in real-time programming have made economical the concept of fully distributed control, leading to the realization of a single system approach from small, several hundred line independent exchanges (and even smaller remote subscriber units) thru the full range of line sizes (to over 100,000 lines) and a full spectrum of applications (local, transit, toll, international and their combinations). These technological advances have indeed led to the development of a single system, fully spanning network applications, the ITT 1240 Digital Exchange. That system has the added advantage of being able to handle non-voice traffic and other new services via extensions and without retrofitting, which feature was indicated in the Introduction as a requirement for guaranteeing that digital equipment installed during the IDN transition will be fully compatible with the subsequent ISDN transition.

BASIS FOR ISDN

The acronym ISDN, integrated services digital network, uses the word "integrated" differently from IDN, integrated digital network. In the latter case, integration refers to the efficient interconnection of transmission and switching equipment. "Integration" in ISDN refers to the accommodation of a variety of communication services on the same transmission and switching facilities in a manner to be described. When individual data and digital-voice calls have access to the same channels (time slots) and when digital switching systems set up both voice and data calls, the network is said to handle integrated services. Services include voice (via PCM encoding), synchronous and asynchronous data, packetized data and voice, facsimile, meter reading and security services, telex and teletex, teletext, etc.

Before the methods for integration are discussed, it is proper to consider what level of service integration is economically and operationally justified and the relation between an integrated network (ISDN) and existing, separate data networks.

The current voice telephone network is characterized by an enormous investment in existing equipment and physical structures. Even with this huge sunk investment the cost-per-subscriber for a basic telephone service is quite low, a consequence of the great number of subscribers. This situation appears in figure 2(a) as a long, low rectangle. In contrast, data services are now characterized by small numbers of subscribers and attendant high per-subscriber investments and resulting high tariffs; two such data services are shown by tall, narrow rectangles at the left of figure 2(a). (Data traffic carried by acoustical coupling or modems via telephonically signaled and set-up calls is counted as ordinary voice traffic.)

If one of the data services in figure 2(a) were offered to all telephone subscribers, the new capital investment for equipment would be quite large and the resulting tariff-per-subscriber would raise the telephony rectangle to the long dotted level shown in figure 2(b). This level of investment and tariff (to every subscriber) is probably unacceptable for both the telecommunications provider and the subscriber. Alternatively some sub-group of subscribers could be offered the service with a far smaller total investment by the administration and a somewhat higher per-subscriber tariff, but a tariff still acceptable to the specialized subscriber; note the dashed rectangle on the left in figure 2(b). Adding other services for all subscribers or for specialized subscriber groups will raise their rectangles, but not by the same margin as the first increase. Integration can thus be full or partial in two ways: some services integrated and some remain separate; and certain services offered to some part of the subscriber population.

There are market and technology trends that will affect these comments, and these are shown as a trend arrow in figure 2(b) -- numbers of subscribers for data services will increase substantially thus lowering costs, while technology advances will reduce equipment costs. As a result, whether full or partial integration is considered, the costs and tariffs will decrease.

Services' characteristics also affect the acceptability and economic advantage of integration. The primary affecting attributes are bandwidth, reliability and call set-up time. When services have markedly different attributes their integration is not convenient. As a result it is unlikely that full service integration will ever be implemented; instead it can be foreseen that services will be grouped by similar requirements and these groupings will be carried by a number of ISDN's with possible interconnections between these networks and probable sharing of transmission facilities.

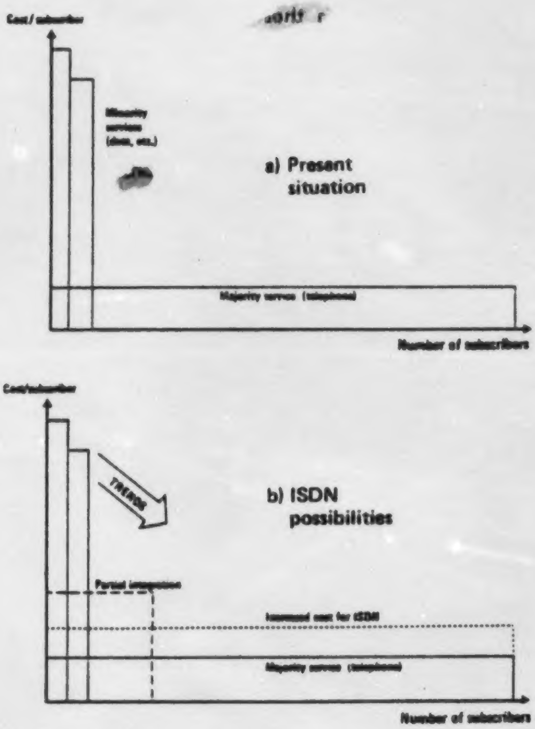


Figure 2. Economic basis for ISDN.

Regarding the bandwidth attribute, surveys have shown that virtually all data requirements, with the clear exceptions of moving video (including video-phone) and certain computer-to-computer communications, will be met by the 64K bit stream now standardized by CCITT recommendations (in the 80K bit line rate). It would be unjustifiably expensive to make video's megabit requirements the standard. For this reason, separate networks will be provided for the majority digital voice and data services and for video-rate services -- to the economic advantage of each.

It should also be clear that major reliability or error-rate differences cannot be accommodated economically on the same network. For example, it would be far more expensive to improve the entire communications network's reliability to the level required by certain civil defense or military services than to provide these services via separate facilities. Similarly, digital voice transmission has a rather moderate error-rate requirement, missing bits or losing a frame resulting in some acceptable noise; but data (bank transfers, meter reading, computer-to-computer messages) cannot tolerate such error rates. Therefore data users have the choice of using the public network with its low tariff and providing error control at their terminals (external to network) or using a separate, low error-rate network.

The last important attribute is call set-up time. When data users send large numbers of very short messages, telephonic set-up times can be as long as the messages themselves. Short set-up time data exchanges are one solution, but at the cost of separate facilities which may be expensive compared with the basic

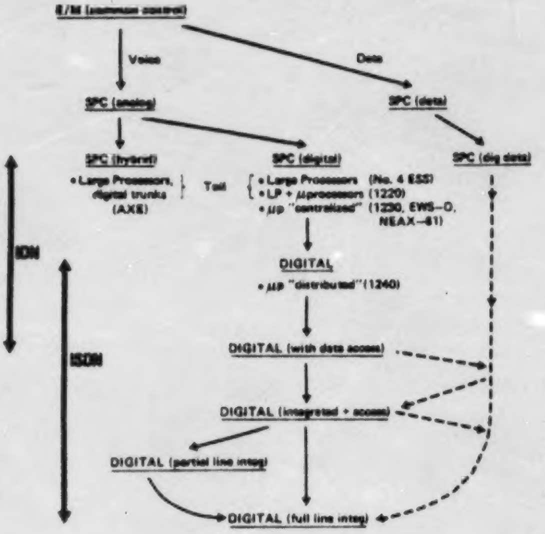

E/M (common control)
Voice
Data
SPC (analog)
SPC (data)
SPC (hybrid)
SPC (digital)
SPC (dig data)
• Large Processors, digital trunks (AXE)
Toll
• Large Processors (No. 4 ESS)
• LP + μprocessors (1220)
• μp "centralized" (1230, EWS-D, NEAX-61)
IDN
DIGITAL
• μp "distributed" (1240)
ISDN
DIGITAL (with data access)
DIGITAL (integrated + access)
DIGITAL (partial line integ)
DIGITAL (full line integ)

Figure 3. Development of digital voice and data switching for the IDN and ISDN eras.

telephone network. These data users must balance the advantages of very short call set-up times and the extra communications cost for a separate network with their adapting to telephonic set-up times and the low cost of using the telephone network. (Administrations have a problem here also, namely of obtaining sufficient revenue from short holding-time calls.)

Consideration of the alternatives presented in the preceeding examples leads to the expectation that rather than there being an integrated services digital network (ISDN) in the future, there will be some number of these networks, ISDN's, each grouping together services whose characteristics and performance requirements are technically similar. For example, the digital voice network will carry a host of data and non-voice services at its 64K-bit rate; there will probably be a network operating at an over 1 megabit rate and grouping TV, video-telephone and high-speed computer messages; other groupings are likely. There will be interconnections between these ISDN's, some in the access sense described immediately below.

While digital introduction has begun in several countries and integrated services planning is starting, separate data networks are currently in being or are in their installation phases. Telephone administration investments in these new data networks must be protected, as there will be a substantial period of coexistence for digital telephony exchanges and data networks. Since the integrated digital network offers a highway for 64K bit data, whether PCM encoded with voice or in a data format, the means can be provided to offer access to data networks for subscribers connected to digital exchanges. In fact it would be proper to consider this form of data network access as the first step toward ISDN. The access stage in service integration can be viewed by the user, the subscriber: his service is generally similar to what it would be if he were directly connected to an ISDN exchange; while from the provider, the administration: it is his choice how to introduce services, his choice whether to access or to integrate them (as it has been his choice whether to route a call via satellite or cable). The provider will therefore make access versus integration decisions based upon economics, equipment capabilities and existing networks. It is therefore quite important to administrations that digital exchanges initially installed for voice telephony be capable of extension for access and later for integration arrangements, the new planning criterion noted in the Introduction.

The access concept offers substantial network opportunities. At present a data user remotely located from a data network can have access to it via modems and use a quite restricted bit rate (due to the essentially 4K Hz capacity of analog trunks), or via a 64K bit capacity digital path, paying the tariff for such a facility devoted solely to his use. Alternatively, the availability of access-capable digital exchanges in the network near the data user provides that user with access to the existing data network via his 64K bit local loop. Initially access may be via telephonic signaling, with the digital local and intermediate exchanges becoming "transparent" after establishment of the connection between the terminal and the data exchange; later there will be direct data signaling to the digital exchange on specifically digital data lines and finally on alternative voice-data lines. (Due to a lack of international standards for digital line signaling, the last arrangement will be delayed until CCITT agreed recommendations are obtained.)

The combination of market development and technology status together with services' characteristics will determine which non-voice services will be integrated with the basic, mostly voice, digital network, which services will be grouped onto specialized-user networks and which will remain as separate services; and finally what access will be provided between these groupings.

SCENARIOS FOR IDN AND ISDN

With a digital switching system capable of the broad size range and application scope noted earlier and with the inherent capability to be extended with both voice and non-voice services, a host of transition scenarios is possible following the pragmatic recommendations. This degree of flexibility is necessary since administrations are starting from quite different situations and have quite different forecasts.

There are many scenarios for the IDN and ISDN transitions and one administration may choose to follow different scenarios in different parts of its network. The steps toward IDN and ISDN are displayed in figure 3 and from these steps actual administration paths can be selected. (The diagram is also a chronology of exchange and network developments.) The starting point with electromechanical exchanges ("E/M" at the top of the figure) splits into two SPC directions, the voice network on the left and data networks on the right. Data networks continue independently thru most of the vertical time span. Following the voice network progression, analog SPC exchanges lead to hybrid SPC exchanges and digital SPC exchanges and the IDN era begins (see arrow on left). The SPC-analog, SPC-hybrid and SPC-digital all employ large central processors. SPC-hybrid exchanges have analog line stages and digital group or trunk stages and they represent an intermediate step toward the fully digital exchange; an analysis of their network application appears in reference 5. (An example of this exchange structure is L M Ericsson's AXE series.)

The first fully digital SPC exchanges were designed for toll or transit applications, since even in wholly analog environments they are more economical than analog toll exchanges. They employ large central processors and their range is limited to medium to large transit applications. Some units use microprocessors to handle certain control functions, an initial form of decentralized control. (Examples here include the Bell System's No. 4 ESS toll exchange and the ITT 1220 transit, the latter including microprocessor control decentralization; the Thompson-CSF MT-20 is essentially the same design as the ITT 1220.)

With the increasing computing power of microprocessors, it has become economical to design the entire exchange control structure with microprocessors rather than with mini-computers or full-size computers. But generally these microprocessors have been applied in a centralized or partially decentralized manner. In the former case, multi-processing configurations allow a cluster of microprocessors to develop a large processing capacity; for the latter technique, so-called front-end (line stage) and back-end (group stage) control points are established in an exchange structure with microprocessors clusters. Neither of these cases constitute distributed control. (Examples include the ITT 1230 small local, now discontinued in favor of the ITT 1240, the size range of Siemens' EWSD system that employs microprocessor control only, and NEC's NEAX-61.) These developments are shown in figure 3 under "SPC (digital)" as "µp centralized" to indicate the centralized structural control role of the microprocessors; note that this exchange design, unlike those above it in the figure, is suited for both local and transit applications.

The most recent development in exchange architecture is fully distributed control (in the figure: DIGITAL, µp "distributed"), in which control functions are provided throughout an exchange, with control capacity and memory allocated to the exchange's functional subsystems as required. This distribution of control applies to the switching matrix as well as to areas like line concentration or translation or call charging. (The following section of this paper includes a description of a fully distributed control digital exchange, the ITT 1240, and its accommodation of voice and data traffic.) With such a digital exchange the next step in figure 3 is possible, namely, access to data networks, as it has already been defined. This step is shown as the arrow from "DIGITAL (with data access)" to the separate data networks on the right. (In the figure, "DIGITAL" represents fully distributed control digital exchanges.) Data integration will follow, with exchanges handling both integration of some services and access to others. Whether the next step will be to provide these facilities on all lines in an exchange, indicated by "DIGITAL (full line integration)", or via an intermediate step in which some lines have these features, "DIGITAL (partial line integration)", is a decision for each administration.

The IDN and ISDN eras, marked by arrows on the left in figure 3, overlap and an administration's progress thru these eras may include all the steps shown or some may be skipped. Considering all the different paths, the uncertainty of future planning due to expected further advances in technology, the multitude of data traffic types known now and the probability that new data or other non-voice services will be required within the operational lifetimes of the digital exchanges installed in the next years -- considering all these possibilities facing administrations in their network planning for IDN and beyond, there is a clear requirement for a solution with a single digital switching system which:

- will provide new services via equipment extensions that do not require modification of already installed equipment;
- can be extended in the future with equipment taking advantage of later technology and without rearrangement of the existing installation;
- will cover the full range of line and trunk sizes (economic for small independent rural exchanges that can grow into 100,000 line exchanges);
- will be applicable as local and toll and combined exchanges;
- fully meets the "pragmatic" introduction recommendations for IDN and thru to ISDN; and
- has the basic flexibility to meet the requirements of existing networks (rather than requiring network modifications to meet the new switching system's needs).

The resulting combination of equipment capabilities and the pragmatic introduction doctrine allows an administration full choice of which services to introduce, and where and when in the network to introduce them, while fully meeting the growth and modernization needs of the basic telephone network (IDN). The next section will describe an exchange structure that can satisfy the requirements listed above.

EXCHANGE ARCHITECTURE FOR ISDN

Having resolved the choices on service integration and access just described, introduction strategies for ISDN are needed, as was the case for IDN. A program of economic, network and technology studies has been initiated, in many ways paralleling the IDN studies reported earlier in this paper. There have been several important conclusions, all of which continue to support the pragmatic strategy for digital introduction. What is new is the requirement that the digital equipment introduced in progress toward IDN be capable of handling the data services access and integration steps toward ISDN that were outlined in the previous section. Remaining is the need to demonstrate that there is a switching system architecture that meets the requirements for economical IDN introduction and later non-voice services handling by means of convenient extensions to the exchange; of course, the exchange must also achieve the other points listed at the end of the last section.

These demands can be met by a fully digital exchange (line stage, internal matrix and group stage) with fully distributed control. A detailed technical description of such an exchange cannot be included here; instead a rather brief outline will be given, sufficient to prove that the structure achieves the criteria listed. The ITT 1240 Digital Exchange will be used to demonstrate the ISDN introduction philosophy, its IDN transition having been presented already. (A technical description of the ITT 1240's system structure, hardware, software, maintenance, etc., appears in a series of seven articles, updated from ICC '80 papers, included in the Supplement to the ITT technical journal, "Electrical Communication", Volume 55, No. 2, 1980.

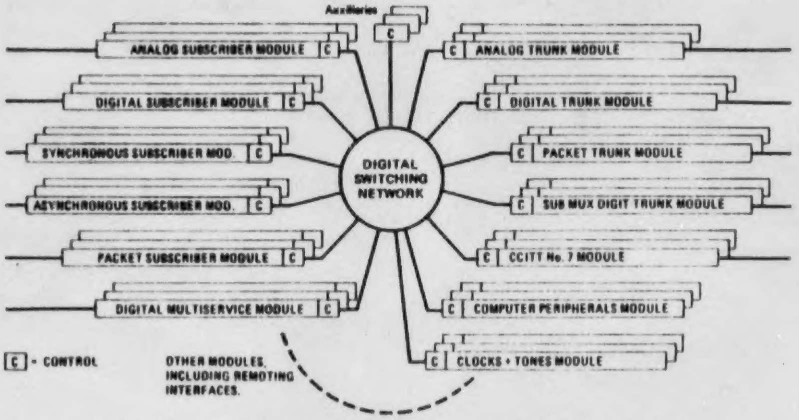

Auxiliaries
C
ANALOG SUBSCRIBER MODULE
C
DIGITAL SUBSCRIBER MODULE
C
SYNCHRONOUS SUBSCRIBER MOD.
C
AEYNCHRONOUS SUBSCRIBER MOD.
C
PACKET SUBSCRIBER MODULE
C
DIGITAL MULTISERVICE MODULE
C
DIGITAL SWITCHING NETWORK
C
ANALOG TRUNK MODULE
C
DIGITAL TRUNK MODULE
C
PACKET TRUNK MODULE
C
SUB MUX DIGIT TRUNK MODULE
C
CCITT No. 7 MODULE
C
COMPUTER PERIPHERALS MODULE
C
CLOCKS + TONES MODULE
C - CONTROL
OTHER MODULES, INCLUDING REMOTING INTERFACES.

Figure 4. ITT 1240 DIGITAL EXCHANGE, architecture consisting of modules for voice and non-voice services.

Copies are available from the Author or the journal's London office.)

The rather simple and quite regular architecture of the ITT 1240 is displayed in figure 4, essentially a Digital Switching Network to which can be connected a quite broad variety of modules, each with its own microprocessor control and memory and each using the same matrix for signaling and subscriber messages. That digital network itself follows the philosophy of distributed control and extension without rearrangement. It is composed of an array of identical Digital Switching Elements, each combining space and time switching functions -- there are no separate time and space switching stages -- as well as each element including its own control. Further these are no complex bus interconnection systems as required by centrally controlled structures. As an exchange grows, switching elements are added for more lines or for increased traffic load so that rearrangement of previously installed switching matrix sections is never required. The memory and control necessary to route a call thru each switching element and thru the whole matrix itself is provided within each element, which needs only the destination address to properly route the call. There is neither an overall control nor a memory map for the matrix. Both subscriber messages consisting of PCM voice and data (duplex) and inter-module signaling (simplex) use the matrix. The matrix is one-sided, calls penetrating only as far into the matrix as is necessary to have logical access to their terminating points. The matrix's structure and liberal dimensioning assure essentially non-blocking service.

The key element in this Digital Switching Network is a single custom LSI chip called a "Switch Port". This patented 4-micron chip contains about 20,000 gates. It behaves as a completely independent switching entity, performing the basic switching function with its own processing and memory resources. Each Switch Port will search, set up and take down digital speech paths and handle connections between microprocessors (signaling) across the exchange. Sixteen of these identical bidirectional Switch Ports, mounted on a single printed circuit board, constitute a Digital Switching Element, the fundamental building block of the Digital Switching Network. Since any of the 16 identical ports may both receive and send messages, and since any incoming channel (any time-slot of a 32 or 24 channel bit stream) of any port can be connected to any outgoing channel (time-slot) of any port, each 16-port Digital Switching Element performs both space- and time-switching functions in the single unit. (For a 32-channel system the 16-port element can be compared, as a combined space and time switch, with a conventional 512x512 matrix.) The diagram of figure 5 indicates this space- and time-switching function, with one call carried between time-slot 14 of port 5 and time-slot 6 of port 16 and another between time-slot 26 of port 3 and time-slot 19 of port 10. Because of their bidirectional capability, Digital Switching Elements are configured as 8x8, 12x4 and 16x0 units according to the applications.

The Digital Switching Network (dashed box in figure 6) is built up progressively to accommodate more lines or higher traffic loads, in each case with no

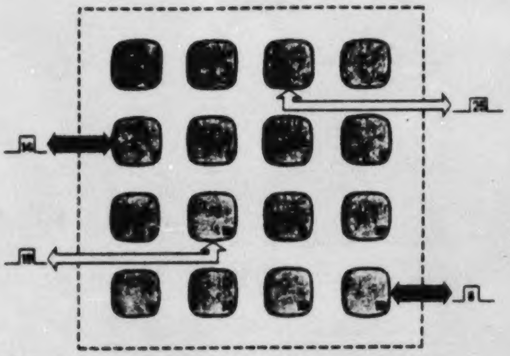


Figure 5. Digital Switching Element, a combined time and space switch

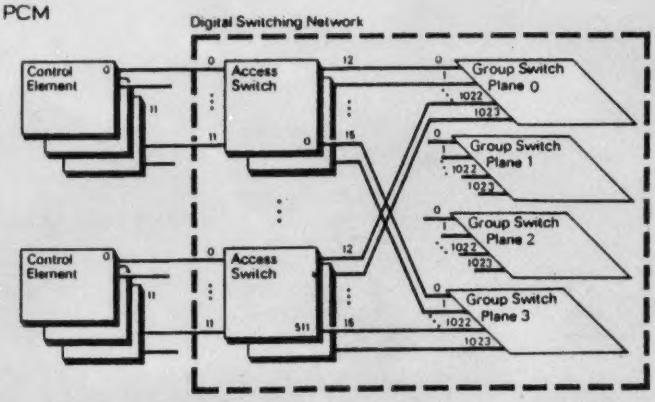

Digital Switching Network
Control Element
0
11
Access Switch
0
11
0
12
15
Group Switch Plane 0
0
1
1022
1023
Group Switch Plane 1
0
1
1022
1023
Group Switch Plane 2
0
1
1022
1023
Group Switch Plane 3
0
1
1022
1023
Control Element
0
11
Access Switch
0
11
511
12
15

Figure 6. ITT 1240 Digital Switching Network and its connection to Module Control Elements.

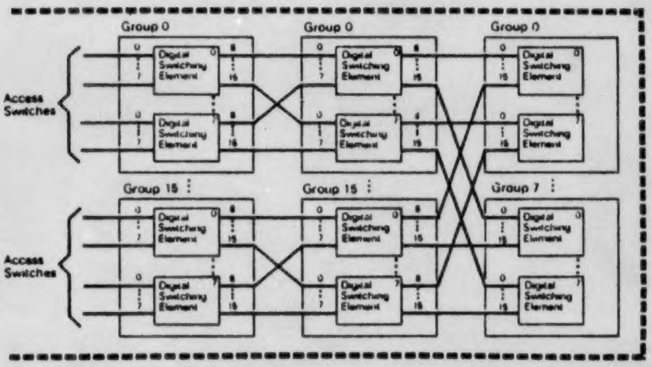

Group 0
Group 0
Group 0
Access Switches
Digital Switching Element
Group 15
Group 15
Group 7
Access Switches
0
7
8
15

Figure 7 Detail of group switch structure for ITT 1240

rearrangement of previously installed network elements. When lines are added, the network grows vertically and horizontally (figures 6 and 7); when traffic loads increase, planes are added. The Access Switches of the network (12x4 configurations of Digital Switching Elements) distribute traffic to the planes of the group switch and are the connecting devices between the group switch and the control elements associated with each exchange module accessing the network (figure 4).

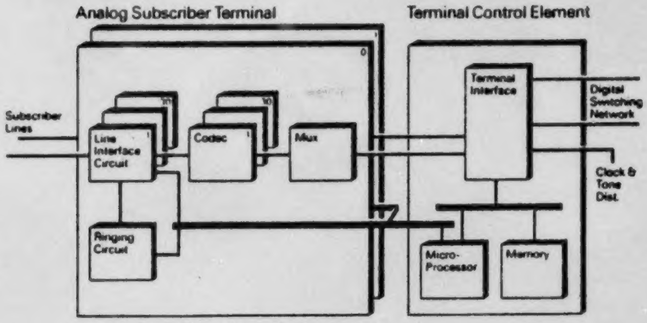
The group switch, detailed in figure 7, is built up of Digital Switching Elements in 8x8 and 16x8 (for the third stage at right in figure) configurations. At the maximum expansion, three stages in the group stage, the exchange can accommodate over 100,000 lines. Up to four "planes" (figure 6) can be installed to handle the heaviest line and trunk traffic load. Expansions by stages (for lines) or planes (for traffic load) are readily accomplished on a "live" exchange.

All modules surrounding the Digital Switching Network in figure 4 have the same structure: each has a Terminal Control Element that interconnects with an Access Switch of the Digital Switching Network (at the left of the dashed box in figure 6). To illustrate this structure two modules are shown in figure 8, an Analog Subscriber Module and a Digital Trunk Module. Both employ a Terminal Control Element, all the "c" boxes in figure 4, comprising an interface, microprocessor and its associated memory. The Analog Subscriber Terminal section of the corresponding module includes the line interface, codex, mux and ringing circuit, while the Digital Trunk Terminal is considerably simpler with its digital trunk circuit. These two modules and the others with identical and self-contained terminal controls, use standardized signaling to access and cross the Digital Switching Network for either simplex or duplex paths.

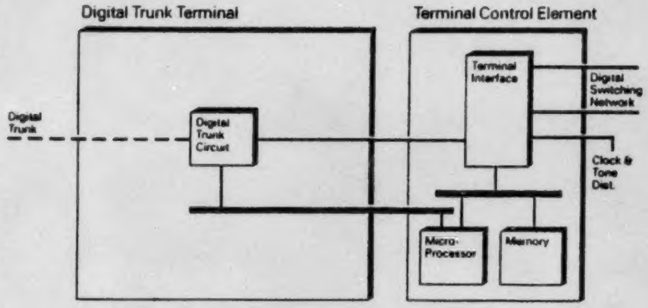
So like the Digital Switching Network that is constructed by a replication of Digital Switching Elements, the modules connected to that network are composed of standardized Terminal Control Elements (interface, microprocessor and its memory), plus their different terminals. This structure does not require a central control point and its reliability and capability for change are enhanced by its distributed control.

Interfaces between the modules and the Access Switches of the switching matrix are rigorously defined and the discipline imposed by these interface definitions is rigourously adhered to so that from the viewpoint of the matrix all modules are identical. Since each module has its own microprocessor control and memory allocation and each uses standard, defined interface procedures for signaling across the matrix to other modules, new modules can be added to the exchange without modifying already installed modules (except for notification of addresses, dimensions, etc.); existing services are extended by increasing the numbers of existing modules, while new services are introduced by installing new modules. The distributed structure also accommodates technological advances that contribute to performance improvements or cost reductions, with exchange extensions in the future employing these improvements for both existing- and new-service modules. Further, via provisioning of modules, the exchange will be configured as a local or transit or a combined unit, and this can change thru the life of the exchange.

The ITT-1240 Digital Exchange just described has been designed for the IDN transition discussed in the first part of this paper, where initially the environment will be largely analog, and subsequently will change to digital; it is also suited, because of its distributed structure, to the wide variety of ISDN transitions that administrations will follow.


Analog Subscriber Terminal
Terminal Control Element
Subscriber Lines
Line Interface Circuit
Codec
Mux
Ringing Circuit
Terminal Interface
Micro-Processor
Memory
Digital Switching Network
Clock & Tone Dist.

a. Analog Subscriber Module.


Digital Trunk Terminal
Terminal Control Element
Digital Trunk
Digital Trunk Circuit
Terminal Interface
Micro-Processor
Memory
Digital Switching Network
Clock & Tone Dist.

b. Digital Trunk Module

Figure 8. Modules for ITT 1240 Digital Exchange.

TRANSITION FROM IDN TO ISDN

The ITT-1240 Digital Exchange, illustrated in figure 4, includes a full complement of modules. In practice only these modules required for an application would be installed. When placed in a wholly analog environment, only Analog Subscriber Modules and Analog Trunk Modules, would be used together with modules required for operations like computer peripherals, clocks and tones, maintenance, etc. (figure 9a). Digital Trunk Modules will be included initially because of the basic economy of digital transmission systems or added later for integration with other digital exchanges, IDN. If there is an existing packet switching network, Packet Subscriber Modules and PacketTrunk Modules are installed to provide access to the packet network (figure 9b). In the same manner access to synchronous and asynchronous data services is provided by the addition of appropriate line-side and trunk-side modules leading to the fully equipped realization introduced earlier in this paper, figure 4. And after providing access to existing data networks, the different levels of non-voice service integration will be implemented. Each of these steps, in any order, will be taken at the convenience of the administration -- timing, choice of services, location -- and without modification of previous installations.

When there is an international standard for the multi-service or alternative voice-data line, Digital Multi-service Subscriber Modules will be installed and they will probably become the only type of line module needed thereafter (that "probably" depending upon current projections of relative module complexities and component costs). Then the exchange in figure 4 will shrink to that in figure 9c with only Analog Subscriber Modules and Digital Multi-service Subscriber Modules in the "line side". Eventually the economics of analog services compared to digital ones will lead to the final configuration, figure 9d, the fully digital network carrying a multiplicity of voice and non-voice services on one of the several ISDN's.

As was stated in the Introduction, there is a great uncertainty in predicting future non-voice services and therefore the form of the multi-service module in 10 or 15 years may be quite different from present expectations. The ITT 1240 structure will be capable of carrying those new services by the addition of new modules -- proving the point raised at the opening of this section that a "future-safe" digital exchange is a reality and its application, "pragmatically", in the world's networks for the transition to IDN is economical and operationally convenient. The very same is true for the transition to ISDN with the guarantee that equipment (administrations' investments) introduced for IDN will be fully utilized for ISDN.

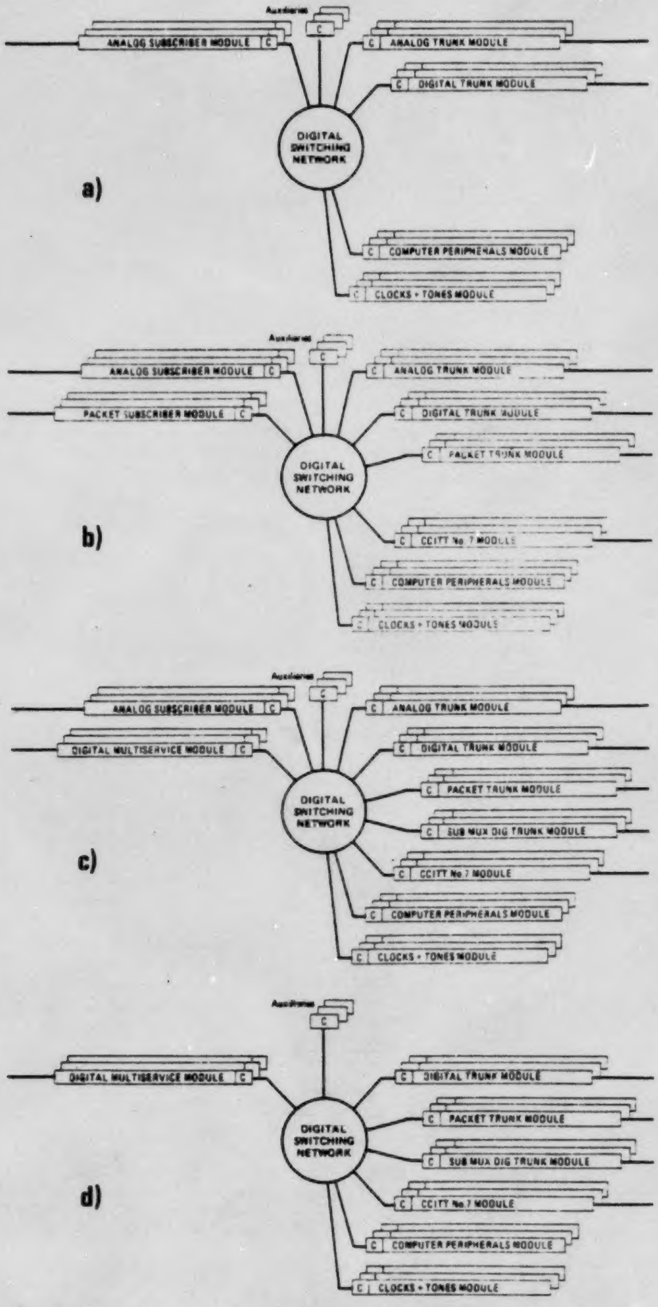


Figure 9. Further evolution of an ITT 1240 Digital Exchange from IDN thru ISDN.

Note: Copies of a more complete report on this subject and copies of ITT's technical journal, "Electrical Communication", containing the ITT 1240 article series referred to in the text are available from the Author at --

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OUTLINE OF NTT'S NEW PUBLIC SWITCHED DATA SERVICE AND ITS MARKETING

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Abstract

In order to meet recent diverse data communication demands, Nippon Telegraph & Telephone Public Corporation (NTT) recently implemented a high-speed, high-quality service called the New Public Switched Data Service. There are two types of new public network services (i.e., circuit switched service and packet switched service), which were put into service in December 1979, and July 1980, respectively. This paper describes the characteristics, tariffs and future marketing applications of the two services.

1. INTRODUCTION

NTT has been providing specified circuit service (leased circuit service) and public network circuit service (dial telephone or telex network service) for data communication use. However, these two kinds of services have several disadvantages. Specified circuit service, for example, is restricted in that the destination is fixed and the charges are expensive for small-volume users. This last restriction is because of the flat rate charging system. At the same time, the public network circuit service is restricted due to low transmission speed, low transmission quality and long set-up time for calls. These three restrictions exist because the network was originally designed for telephone or telex service. Therefore, to meet needs for high-speed, high-quality, volume-sensitive rate switched network service, NTT has been developing a new public switched data service. They consist of circuit switched service and packet switched service, which were put into service in December 1979 and July 1980, respectively.

This paper (1) describes the present status of data communication circuits, (2) gives a general outline of both the circuit switched service and packet switched service and (3) outlines marketing objectives for the future.

2. PRESENT STATUS OF DATA COMMUNICATION CIRCUITS

NTT provides data communication circuit service for data communication use. In the data communication facility service, NTT provides all facilities such as computers, data terminal equipment and data communication circuits. On the other hand, in the data communication circuit service, NTT only provides the communication circuits for data communication systems, with customers arranging for the other facilities. Data communication circuit service is classified into two categories, i.e. specified circuit service and public network circuit service. Circuit switched service and packet switched service are not established formally in accordance with public telecommunications law. They are provided as tentative services.

2.1 SPECIFIED CIRCUIT SERVICE

Specified circuits are special leased circuits for data communication use. Customer-owned data communication components, such as computers and data terminal equipment, can be interconnected via NTT's communication circuits. Table 1 shows the types of specified circuits.

Table 1: TYPES OF SPECIFIED CIRCUIT

Type of Circuit			Characteristics
Frequency Band Series	Type D (3.4 KHz)	D-1 (Band usage)	Capable of transmission, under normal conditions, on a bandwidth of 0.3 – 3.4 KHz.
		D-1S (Band usage, special) (Note 1)	Capable of transmission, under normal conditions, on a bandwidth of 0.3 – 3.4 KHz. Transmission characteristics are conditioned.
		D-5 (1,200 b/s code transmission)	Capable of code transmission at up to 1,200 bits per second.
		D-7 (2,400 b/s code transmission)	Capable of code transmission at 2,400 bits per second.
		D-9 (4,800 b/s code transmission)	Capable of code transmission at 4,800 bits per second.
		D-13 (9,600 b/s code transmission)	Capable of code transmission at 9,600 bits per second.
	Type I (48 KHz)	I-1 (Band usage)	Capable of code transmission, under normal conditions, on a bandwidth of 60 Hz – 108 KHz.
		I-3 (48 Kb/s code transmission)	Capable of code transmission at 48 kilobits per second.
	Type J	J-1 (Band usage)	Capable of transmission, under normal conditions, on a bandwidth of 312 KHz – 552 KHz.

Code Transmission Series	50 b/s	Capable of code transmission at up to 50 bits per second.
	100 b/s	Capable of code transmission at up to 100 bits per second.
	200 b/s	Capable of code transmission at up to 200 bits per second.
	300 b/s	Capable of code transmission at up to 300 bits per second.
	1,200 b/s	Capable of code transmission at up to 1,200 bits per second.
	2,400 b/s	Capable of code transmission at 2,400 bits per second.
	4,800 b/s	Capable of code transmission at 4,800 bits per second.
	9,600 b/s	Capable of code transmission at 9,600 bits per second.
	48 Kb/s	Capable of code transmission at 48 kilobits per second.

2.2 PUBLIC NETWORK CIRCUIT SERVICE

The public network circuit service allows customers to connect their computers to their data terminal equipment over NTT dial telephone and telex networks. Transmission characteristics and rates are the same as those of ordinary dial telephone and telex lines. Table 2 shows the types of public network circuits.

Table 2: TYPES OF PUBLIC NETWORK CIRCUITS

Type of Circuit	Transmission Speed
Public telephone network circuit	Capable of code transmission at approximately up to 1,200 b/s in an alternating current mode.
Public telex network circuit	Capable of code transmission at up to 50 b/s in a direct current mode.

2.3 NUMBER OF DATA COMMUNICATION CIRCUITS

Table 3 shows the number of data communication circuits. As of March 1980, there were 83,515 specified circuits, and 23,571 public network circuits in operation. The number of data communication circuits has been increasing every year. The increase in the number of public network circuits has been particularly rapid. This growth is expected to continue for the foreseeable future. Thus, it is estimated that new public switched network demand for data communication will be strong.

Table 3: NUMBER OF DATA COMMUNICATION CIRCUITS

As of March / Classification	1975	1976	1977	1978	1979	1980
Specified Circuits	33,533 (100)	45,525 (136)	52,631 (157)	58,977 (176)	67,422 (201)	83,515 (249)
Public Network Circuits	2,626 (100)	5,245 (200)	8,565 (326)	12,117 (461)	16,217 (618)	23,571 (898)
Total	36,159 (100)	50,770 (140)	61,196 (169)	71,094 (197)	83,639 (231)	107,086 (296)

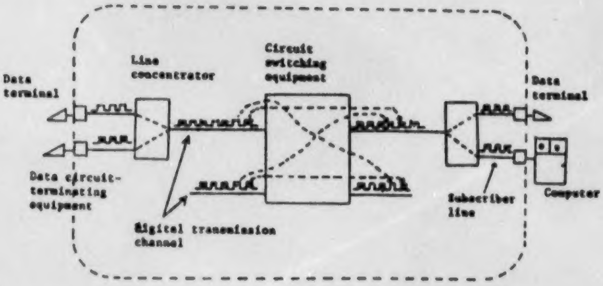
Figures in parenthesis shows indexes (1975 = 100).

3. GENERAL OUTLINE OF CIRCUIT SWITCHED SERVICE

3.1 FUNDAMENTAL SYSTEM CONFIGURATION

In the circuit switched service utilizing time division switching technology and digital transmission technology, a high-speed, high-quality unblocked channel is exclusively provided between the calling data terminal equipment and the receiving equipment throughout the duration of the call. This is similar to telephone switching. The circuit switched network consists of circuit switching exchange and line concentrators. Data terminal equipment is connected to a line concentrator through the data circuit-terminating equipment and subscriber lines, as illustrated in Fig. 1.

Fig. 1: CIRCUIT SWITCHED NETWORK


Data terminal
Line concentrator
Circuit switching equipment
Data terminal
Data circuit-terminating equipment
Digital transmission channel
Subscriber line
Computer

3.2 SPECIFICATIONS

Circuit switched service incorporates, for the most part, International Telegraph and Telephone Consultative Committee (CCITT) recommendations as follows:

(1) This service supports new X series terminals and existing V series terminals defined by CCITT Group III.

(2) The types of circuits are classified into seven categories, from 200 b/s start-stop to 48K b/s synchronous corresponding to the transmission speed of the data terminal equipment, as shown in Table 4.

Table 4: TYPES OF CIRCUITS IN CIRCUIT SWITCHED SERVICE

Type of Circuit	Characteristics
200 b/s (start-stop)	Capable of code transmission at up to 200 bits per second
300 b/s (")	Capable of code transmission at up to 300 bits per second
1,200 b/s (")	Capable of code transmission at up to 1,200 bits per second
2,400 b/s (synchronous)	Capable of code transmission at 2,400 bits per second
4,800 b/s (")	Capable of code transmission at 4,800 bits per second
9,600 b/s (")	Capable of code transmission at 9,600 bits per second
48K b/s (")	Capable of code transmission at 48 kilobits per second

(3) Except for 600 b/s synchronous and 1,200 b/s start-stop circuits, these circuits are in accordance with CCITT Recommendation X.1. The 600 b/s synchronous circuit is not included in

service since demand forecasts for this class are very low. On the other hand, 1,200 b/s start-stop circuit has been specially included, since there are many data terminals in Japan using this type of circuit.

(4) The data terminal equipment (DTE) - data circuit-terminating equipment (DCE) interface for start-stop terminals is based on CCITT Recommendation X. 20 and X. 20 bis. The interface for synchronous terminals is based on CCITT Recommendation X. 21 and X. 21 bis.

(5) Users can communicate with any circuits of the same category.

3.3 RATE

The rates for this service have been determined by taking into account the service cost as well as the relationship with existing services, such as specified circuit service and public network circuit service. The main points of the rates are as follows:

(1) The rates are composed of monthly charges and call charges. The call charges are based on call duration.

(2) The Classification of the basic monthly rate depends on the types of circuits involved.

(3) In the call charge, the same periodic pulse metering method, applied to telephone service, is adopted. Charge steps are classified into eight categories, which are almost the same as specified circuit service.

Table 5: TARIFF FOR CIRCUIT SWITCHED SERVICES

Classification	One-time charges at Initial Installation			Basic monthly rate	Call Charges								
					Unit rate	Transmission time allowed for unit rete							
	Subscription Fee	Installation Charge	Bonds			Local call	Adjacent call, up to 30 km	Up to 60 km	Up to 120 km	Up to 240 km	Up to 420 km	Up to 750 km	Over 750 km
200 b/s	300 yen	140,000 yen	650,000 yen	18,000 yen	10 yen	120 sec.	90 sec.	65 sec.	40 sec.	25 sec.	17 sec.	13 sec.	11 sec.
300 b/s	300	140,000	650,000	18,000		100	80	55	35	22	14	11	9
1,200 b/s	300	140,000	650,000	20,000		60	45	30	18	11	7.5	6	5
2,400 b/s	300	140,000	650,000	22,000		55	40	27	17	10	7	5.5	4.5
4,800 b/s	300	140,000	750,000	24,000		50	35	25	15	9	6.5	5	4
9,600 b/s	300	140,000	900,000	26,000		45	30	20	14	8	6	4.5	3.5
48 Kb/s	300	140,000	2,200,000	30,000	20	12	8	5.5	4.5	3.5	2.5	1.5	1

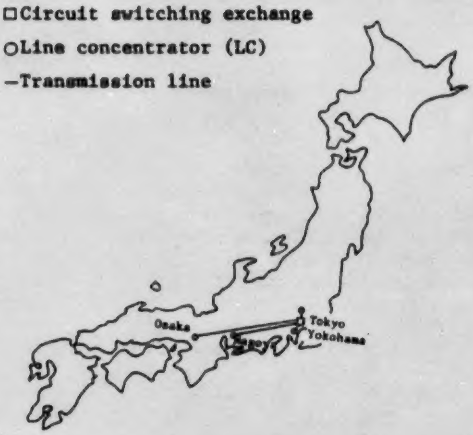
(4) Because of the more efficient use of transmission circuits, disparity between short-haul and long-haul call charges is more reduced than those of specified circuit service and public network circuit service. (Tariff is shown in Table 5).

3.4 SERVICE AREAS

NTT service areas cover Tokyo, Osaka, Nagoya and Yokohama. The circuit switching exchange is installed in Tokyo and line concentrators are installed in four cities as shown in Fig. 2.

Fig. 2: CIRCUIT SWITCHED SERVICE AREAS

Note: □Circuit switching exchange
○Line concentrator (LC)
—Transmission line



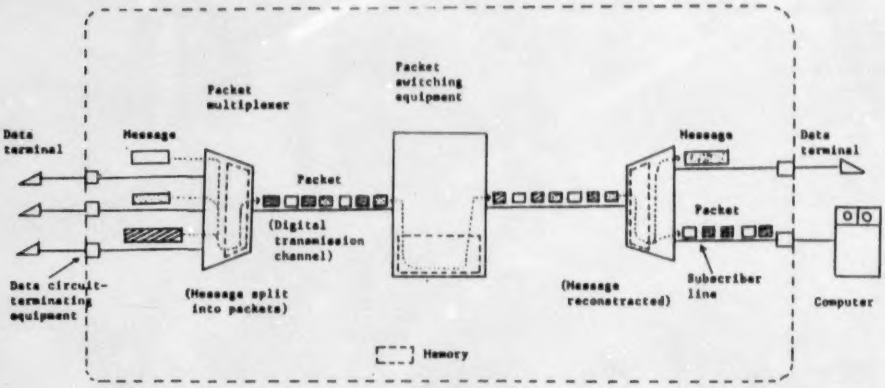
They are Tokyo, Osaka, Nagoya and Yokohama. The reason for this choice of locations is that these are the four main cities in Japan and the largest demands for this service are forecast for these areas. The distance between Tokyo and Osaka is about 500km, between Tokyo and Nagoya is about 280km and between Tokyo and Yokohama is about 30km.

4. GENERAL OUTLINE OF PACKET SWITCHED SERVICE

4.1 FUNDAMENTAL SYSTEM CONFIGURATION

In packet switched service, utilizing store-and-forward switching technology and digital transmission technology, an oriented message is temporarily stored in the switch and split into fixed length segments called packets. The switch adds the destination address to each packet and forwards it to the destination exchange. The destination exchange reads the address of the received packet and delivers it to the receiving data terminal equipment. The packet switched network consists of packet switching exchange and packet multiplexers. Data terminal equipment is connected to this network through data circuit terminating equipment and subscriber lines, as illustrated in Fig. 3.

Fig. 3: PACKET SWITCHED NETWORK



4.2 SPECIFICATIONS

As is the case with circuit switched service, packet switched service incorporates, for the most part, the CCITT Recommendations as follows:

(1) This service supports new X series terminals and existing V series terminals defined by CCITT.

(2) Data terminal equipment is classified into two categories: Packet mode terminal (PT), which has packet assembling and disassembling function like computers, and a Non-packet mode terminal (NPT), which does not have these functions.

(3) There are seven types of circuits in this service. They are classified from 200 b/s start-stop to 48k b/s synchronous. This is the same as in circuit switched service, as shown in Table 6. PT circuits range from 2,400 b/s to 48k b/s. NPT circuits range from 200 b/s to 9,600 b/s.

Table 6: TYPES OF CIRCUITS IN PACKET SWITCHED SERVICE

Type of Circuit	Characteristics	PT	NPT
200 b/s (start-stop)	Capable of code transmission at 200 bits per second	—	0
300 b/s (")	Capable of code transmission at 300 bits per second	—	0
1,200 b/s (")	Capable of code transmission at 1,200 bits per second	—	0
2,400 b/s (synchronous)	Capable of code transmission at 2,400 bits per second	0	0
4,800 b/s (")	Capable of code transmission at 4,800 bits per second	0	0
9,600 b/s (")	Capable of code transmission at 9,600 bits per second	0	0
48K b/s (")	Capable of code transmission at 48 kilobits per second	0	—

(4) The interface between a packet mode DTE and a DCE is based on CCITT Recomendation X. 25. The interface between a non packet mode DTE and a DCE is based on CCITT Series X Recommendations.

(5) Transmission control procedures applicable in this service, are shown in Table 7.

Table 7: POSSIBLE DTE TRANSMISSION CONTROL PROCEDURES COMBINATION

Calling Party	Called Party	PT	NPT			
	Transmission Control Procedure	HDLC	(1)	(2)	(3)	(4)
PT	HDLC	o	o	o	o	o
NPT	(1) HDLC	o	o	-	-	o
	(2) Basic mode, conversational	o	-	o	-	-
	(3) Basic mode, full duplex	o	-	-	o	-
	(4) Delimiter	o	o	-	-	o

Data terminal equipment using different procedures can communicate with each other within the provisional restriction shown in Table 7.

(6) Basic facility in this service is virtual call, but permanent virtual circuit facility is provided to the user facility on an optional basis.

(7) PT can communicate with multiple addresses simultaneously by using many logical channels over a single subscriber line. Logical channels are provided to a user facility on an optional basis.

4.3 RATE

Service rates are set up, taking into account service cost. Main points of the rates are as follows:

(1) The rates are composed of monthly charges and call charges. The call charges are based on transmitted message volume, not call duration.

(2) Basic monthly rate is classified depending on the types of circuits involved.

(3) The same call charge applies to all types of circuits, but the call charge varies depending on charge steps.

(4) Because transmission circuits are more efficient than circuit switched service, their charges are less for both short and long-haul calls. Charge steps are classified into three categories. In setting up the distance in steps, economic block elements were taken into consideration.

(5) The maximum size for one packet is 256 octetes. Half of this amount, 128 octetes, is set as the charge unit. (Tariff is shown in Table 8).

4.4 SERVICE AREAS

NTT service areas covers Tokyo, Osaka, Nagoya, Yokohama, Fukuoka, Sendai and Sapporo. The packet switching exchange is installed in Tokyo. Packet multiplexers are installed in all these cities, as shown in Fig. 4.

Fig. 4: PACKET SWITCHED SERVICE AREA

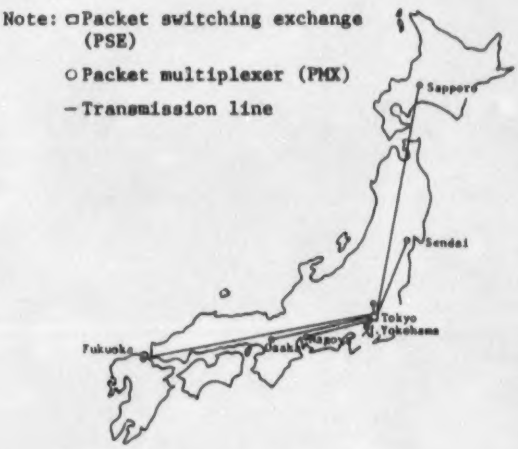

Note: □Packet switching exchange (PSE)
○Packet multiplexer (PMX)
–Transmission line
Sapporo
Sendai
Tokyo
Yokohama
Nagoya
Osaka
Fukuoka

Table 8: TARIFF FOR PACKET SWITCHED SERVICES (IN YEN)

Classification	One-time charges at initial installation			Monthly Charges	Call Charges		
					Message Rate (per 128 Octetes)		
	Subscription fee	Installation charges	Bonds	Basic rate	Up to 100 km	Up to 500 km	Over 500 km
200 b/s	300	110,000	900,000	16,000	0.4	0.5	0.6
300 b/s	300	110,000	900,000	16,000			
1,200 b/s	300	140,000	1,000,000	22,000			
2,400 b/s	300	140,000	1,100,000	26,000			
4,800 b/s	300	140,000	1,100,000	28,000			
9,600 b/s	300	140,000	1,100,000	30,000			
48 Kb/s	300	140,000	2,200,000	75,000			

More cities have been included in the packet switched service than the circuit switched service because of greater projected demand. The distance between Tokyo and Fukuoka is about 800km, between Tokyo and Sendai about 300km, and between Tokyo and Sapporo about 800km.

5. OPTIONAL USER FACILITIES

5.1 OPTIONAL USER FACILITIES IN THE NETWORKS

The following optional user facilities are avialable to each data terminal in these services.

(1) Closed User Group — No calls out of or into a closed user group are permitted.

(2) Direct Call — A call is set up to the registered terminal without dialing.

(3) Calling and Called Line Identification — Network informs calling and called terminal of called and calling line identification.

(4) Abbreviated Address Calling — A call is set up by dialing only two registered digits.

(5) Lump-sum Payment — A registered terminal is charged for all calls to or from this terminal.

(6) Logical Channels and Permanent Virtual Circuit — These two facilities are provided only in packet switched service.

5.2 DATA TERMINAL EQUIPMENT

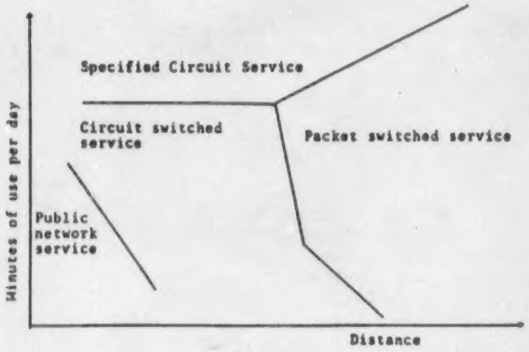
In New Public Switched Data Service, NTT only provides switching equipment and channels and leaves the provision of computers and data terminal equipment to the customer. However, NTT's policy is to provide certain types of standard terminals. (e.g., NTT is now providing 300 b/s keyboard printers as its standard terminal).

6. APPLICABILITY

Given characteristics of technology and the rate structure, circuit switched service is suited for the transmission of longer and high-density data, while packet switched service is best used for the shorter and much sparser data transmission.

NTT is now providing three kinds of data communication circuits, with circuits of new public switched data service as a new product: specified circuits (flat rate), public network circuits (message rate) and the circuits of new public switched data service. It is up to the users to select what to use from among these three kinds of circuits. The main criteria for the choice will be distance, time and traffic volume of the planned system. Figure 5 shows an economic comparison of these services. Public switched circuits are suitable where the transmitted amount of data is small and the transmission distance is short. Specified circuits are suitable where the transmitted amount of data is large. Packet switched service is suitable where the transmission distance is great. Circuit switched service will be selected to cover the intermediate areas.

Fig. 5: ECONOMIC COMPARISON CHART



7. MARKETING OBJECTIVES FOR THE FUTURE

Since NTT's new public switched data service has only just started, in order to meet customer requirements, it is necessary to try to make the service as complete as possible. The following are some of the marketing objectives now being planned.

7.1 INCREASED SERVICE AREAS

There are only four cities with circuit switched service and only seven cities with packet switched service. Many of the data communication systems are formed on nationwide networks. Service areas limitation may be an obstacle in developing these two services. In order to enhance the efficiency of public network and increase the number of subsribers, it is desirable to extend these services to the rest of the country in the near future. At the moment, NTT is planning to increase the number of service areas to about 30 to 35 cities by the end of 1982.

7.2 ADDING THE OPTIONAL USER FACILITIES

NTT is now providing five kinds of optional user facilities in circuit switching service and seven kinds in packet switched service. More convenient optional user facilities are planned as follows:

(1) The circuit switched service will include Multi-address calling and Delayed Delivery for facsimile users.

(2) The packet switched service will include kinds of data terminal equipment.

7.3 DEVELOPING VARIOUS TERMINAL EQUIPMENT

NTT is offering a 300 b/s keyboard printer for users. NTT plans various types of terminal equipment such as a high-speed keyboard printer, CRT display and facsimile terminals.

7.4 CONNECTION BETWEEN PACKET SWITCHED NETWORK AND PUBLIC TELEPHONE NETWORK

NTT plans that telephone network users will be able to access the packet switched service user's computer with handy data terminal equipment, such as an acoustic coupler.

7.5 INTERNATIONAL CONNECTION

In Japan, Kokusai Denshin Denwa Co., Ltd. (KDD) is responsible for international connection between Japan and foreign countries. KDD has announced that it will offer a new international digital network service, called Valuable & Efficient Network Utility Service (VENUS), based on packet switching techniques. NTT plans to connect the packet switched service to VENUS in order to realize international connection.

STATE MACHINE ARCHITECTURE IN PERIPHERAL PROCESSING

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ABSTRACT

The methodology described here is used in an EPABX, designed as a hierarchically distributed processing system with microcomputers at the nodes. At the lowest level of the hierarchy, called peripheral processing, a state machine architecture was chosen for the firmware. At each peripheral processor, a microcomputer monitors and controls up to eight units, for example eight telephone sets. The microcomputer firmware provides an application-oriented state machine for each unit, as well as a state machine interpreter and operating system. The design worked well in the limited memory of peripheral processors.

1 INTRODUCTION

This paper describes a design methodology used to program firmware for an electronic private automatic branch exchange (EPABX). The EPABX was developed by BNR Inc., a research and development subsidiary of Northern Telecom and Bell Canada. This system makes extensive use of microprocessors on the various peripheral cards. We chose to use a state-machine architecture for the firmware on these cards. This approach was successful from the viewpoints of portability, modularity, and speed of development.

2 PBX ARCHITECTURE

An EPABX controls and switches a number of peripheral devices: telephones (also referred to as "station sets"), trunk lines, data communication lines, and a variety of specialized units such as conference circuits, modems, and tone generators. Central control in an EPABX is performed by a computer (here referred to as the CPU). The CPU performs such functions as call processing, resource allocation, system self-diagnosis, and fault recovery.

The hardware interface to the actual peripheral devices is on separate circuit boards ("cards") from the CPU. For manufacturing economy and ease of service, one card generally controls several units of the same type. For example, up to 8 telephone sets can be connected to one Analog Line Card. Up to four trunk lines to a nearby public telephone system central office are connected to one CO Trunk Card. See Figure 1.

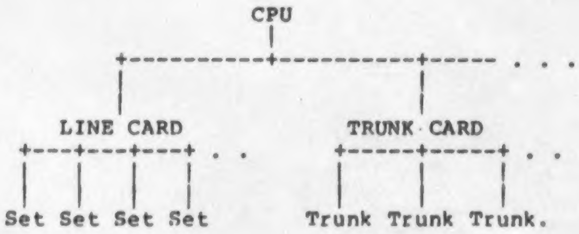

Figure 1: Logical control of peripheral units in an EPABX

In this EPABX, each peripheral card has a microprocessor (uP). It is responsible for DETAILED monitoring and control of the units on its card, while the CPU performs GENERAL control. In this way, the uP relieves the CPU of many of the critical real-time requirements that occur in telephony. For example, when a telephone set receives an incoming call, call processing on the CPU orders the appropriate peripheral card uP to begin ringing the set. The uP controls the actual ring cadence by turning ring-voltages on or off according to a timing sequence, while the CPU goes about other tasks. Single-chip uPs are used (Intel MCS-48) with 2 to 4 Kbytes of program ROM and 64 to 1024 bytes of RAM [1]. For example the ALC uP is an Intel 8039 with a 2KByte program ROM and 128 bytes of on-chip RAM.

The design problem for peripheral-card firmware was to make the control of peripheral units convenient for the software running on the CPU. The CPU call processing software used a state machine approach, and we chose to use a state machine design for our firmware too. Each peripheral unit was to be handled by its own state machine, with the states reflecting the physical status of the unit and the logical status of the call processing. A peripheral card uP would then have multiple state machines, one for each unit connected to the card.

Since the CPU software was message-based, we chose to use a logical message interface with the CPU. In the case of the analog line card (ALC), the CPU can send the following messages: Initialize_card, Start_ring (unit), Stop_ring (unit), etc. The uP can send these messages back to the CPU when it senses some change in a station set: On_hook (unit), Off_hook (unit), Digit_dialled (unit), etc.

Below, we define more fully what we mean by the term "state machine". Then the control of dial-pulse analysis for a rotary dial telephone (or "analog station set") is described as an example of how our state machines work.

3 STATE MACHINES

A state machine for a peripheral unit is composed of

- a set of STATES.
- a set of one or more INPUTS (or sense-point changes) from the unit. This explicitly includes TIMEOUT from a TIMER, which may be set to elapse after a specified time.
- a set of ACTIONS, which include operations to perform on the control points of the unit, and possibly messages sent to the CPU.
- a STATE TRANSITION MATRIX (STM), the cross-product of INPUTS and STATES, which defines what happens to a state machine when an input changes. For a state-input pair, the STM gives a new state and an action to perform.

The state transition diagram is a graphical way to represent a state machine and all its legal transitions. It is not as complete as the STM, but it is easier to understand. See Figure 3 for an example.

3.1 ANALOG LINE CARD

To better explain the state machine design, the analog line card is chosen as an example. The analog line card microcomputer handles up to eight 500 or 2500 type telephone sets. It handles ringing, onhook/offhook recognition, dial pulse digit collection from 500 type sets, and recognision of hookswitch flash.

500 sets are rotary dial telephone sets where dialpulsing is used for signalling purposes, 2500 sets are digitone (NT trade mark) telephones where multifrequency digitones are used for signalling. Onhook is the "idle" condition when the party has the handset on the hook, that is switchhook down. Offhook is the "talk" condition when the party has the handset off the hook, that is switchhook up. When one dials a number after going offhook the set generates a series of onhook-offhook transitions which are called dial pulses. The onhook condition is defined by low current and the offhook by high current.

Dial pulse analysis is chosen as an example. The complete state transition diagram for the ALC firmware has 14 states and is too complex for an example here. The sequence of what happens when one dials 3 is shown in figure 2.

```
Offhook
   +-----+  +---+  +---+  +-----------+
   |     |  |   |  |   |  |           |
   |     |  |   |  |   |  |           |
   |     |  |   |  |   |  |           |
 --+     +--+   +--+   +--+           +--
Onhook
         |--|---|         |-------|
          t1  t2              t3

     -------------> t
```

Figure 2 : Dial Pulse Analysis

t1 is the BREAK time when an onhook signal is sent, t2 is the MAKE time when an offhook signal is sent and t3 is the interdigit time. The timings vary depending on the speed of the rotary dial (10 or 20 pulses per second). t3 is greater than t2 and there are other timings to detect a hookswitch flash, disconnect etc., but for simplification purposes the timing is limited to only t3 here. Dialling 3 produces 3 dial pulses.This is recognised by the state machine, and a digit message is sent to the CPU. From the timing diagram a state transition diagram can be drawn (Figure 3).

```
+---------+
| DIAL    |
|         |  <-------------------+
|(offhook)|  Act2: "digit DP"    |
+---------+        to CPU        |
     |                           |
     |                           |
     |                           |
     |                           |
     v                           | t > t3
+---------+                 +---------+
| BREAK   |  <------------  | MAKE    |
|         |                 |         |
| (onhook)|  -------------> |(offhook)|
+---------+  Act1:DP<--DP+1 +---------+
```

Figure 3: State transition diagram

Following are some notes describing the state transition diagram.

- Three states are defined: dial,break and make.
- Disregarding commands from the CPU, there are only two ways out of a given state: one from a hookswitch sample change (onhook/offhook), and the other from timeout. Not all states have both.
- Sampling of the switch hook status is done on a regular basis, every T msec (where T will be chosen in the range 7..12 msec). Hook switch debouncing is achieved by allowing sample change transitions only if the sample has changed from the expected value on two successive samples. The "two-successive" rule will be implemented entirely in the sampling algorithm so it will not affect the states of the state machine (otherwise transitional states are required for the second sample of two successive).
- Commands from the CPU are not considered to be inputs to the state machine, since there are very few commands and the processing of them is more easily handled as a special case. However the commands can force state changes.

3.2 STATE TRANSITION MATRIX (STM)

From the state transition diagram a state transition matrix is drawn (Figure 4). This is just another way of representation of the state diagram. The current state is shown in the left most column and the next state the machine will go to is shown in the next two columns, one for sense change and the other for timeout. Following the next state are the action columns, again one for hook switch change and the other for timeout. The actual timeout is given in the last column in milliseconds.

Notes on the STM:

- Normally only a hookswitch sample change or timeout can move a SM to a new state but commands from the CPU can put a SM in a new state too.
- If there is no action procedure specified (like Actl), then SM_DRIVER will simply move the SM to the new state without extra action. This situation is marked with "-" above, in the action columns.
- The timeout is specified in milliseconds and a zero in that column means that there is no timeout for that state. For example one could be in talk state (which is not shown here) forever.

4 SM MODULE ORGANIZATION

The analog line card firmware contains several functional modules. To name a few, the message protocol (MP), command processor (CP), global control (GL) and diagnostics (DG). The module that handles the state machines is called SM and it implements a finite-state-machine for each analog telephone set. The collection of procedures that make up the SM module is shown here along with their functions (Figure 5).

4.1 FUNCTIONAL ORGANIZATION OF SM

SM module, the controller of state machines has three top level procedures. They are,

- Initialization of module data
- State machine driver
- Timer interrupt handler

4.1.1 SM_INIT

The initialization of the module data is done during system initialization or after power up reset. It initializes the SM data base (SM_UDATA), which contains the current state information for each unit and the action registers that indicate whether any work is pending for the state machine driver. It cleans up the action registers so that there won´t be any actions pending for the state machine driver routine initially.

Current State	Next State hk_sw change	timeout	Action hk_sw hange	timeout	Timeout (ms)
Dial	Break	Dial	-	-	0
Break	Make	Break	Actl	-	0
Make	Break	Dial	-	Act2	t3

Figure 4: State transition Matrix

4.1.2 SM_DRIVER

SM_DRIVER is the main procedure which is called from the executive loop. This loop has two main functions. It watches for messages from the CPU and calls the SM_DRIVER. This procedure looks for work by scanning the action registers . There could be any number of action registers depending on the requirements. In this example there are two action registers. If these action registers are null, there is nothing to be done,so it returns to the executive loop. If the action registers indicate any work pending, the SM_DRIVER reads the current state of the machine (from RAM) and using the STM finds out the new state it should go to and puts the machine in the new state by calling SM_NEW procedure which drives only one unit per call. When SM_NEW puts that unit in the new state SM_ACTION procedure is called to perform any action necessary, for example, sending a message to CPU or setting up some control point.

4.1.3 SM_TIM_INT

This procedure, called the timer interrupt handler gets called every timer interrupt, ie., every 10 milliseconds. This routine scans the sense points to detect any change and sets up the action register if there is any. It also keeps the timeout counters and when timeout occurs, it updates the action registers.

4.2 MODULARITY

The functional breakdown resulted in a very clean module group structure which was borrowed across the board in all peripheral processors. In the SM module itself the state transition matrix and the action procedures are the only things that need be changed for different cards.

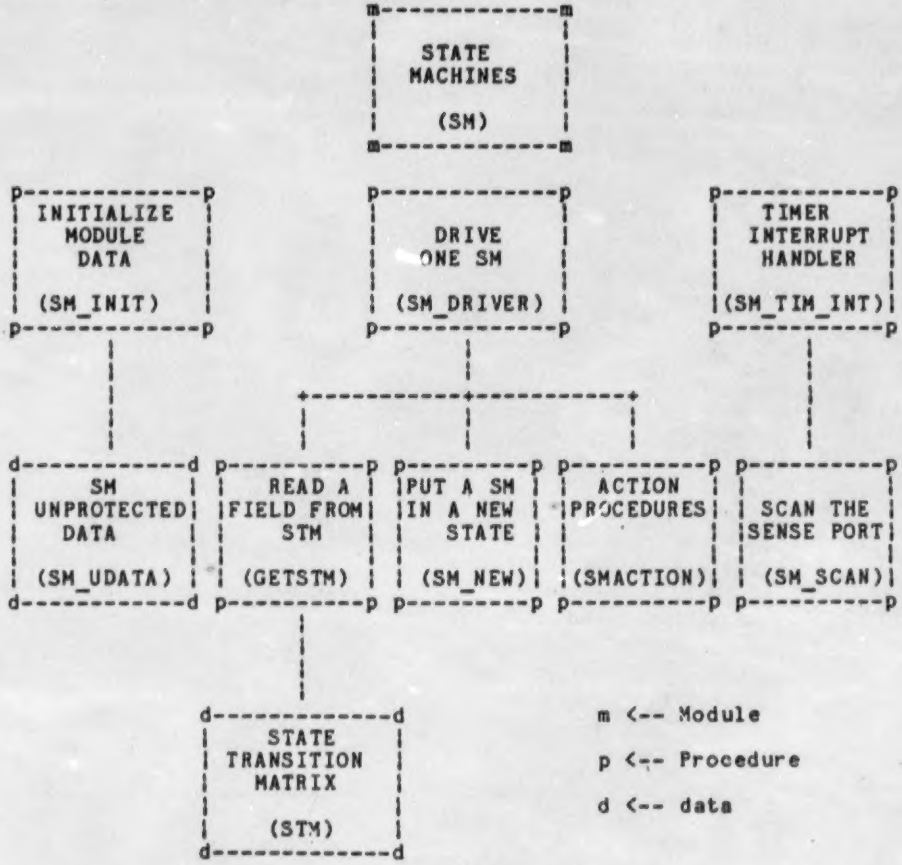
STATE MACHINES (SM)
INITIALIZE MODULE DATA (SM_INIT)
DRIVE ONE SM (SM_DRIVER)
TIMER INTERRUPT HANDLER (SM_TIM_INT)
SM UNPROTECTED DATA (SM_UDATA)
READ A FIELD FROM STM (GETSTM)
PUT A SM IN A NEW STATE (SM_NEW)
ACTION PROCEDURES (SMACTION)
SCAN THE SENSE PORT (SM_SCAN)
STATE TRANSITION MATRIX (STM)
m <-- Module
p <-- Procedure
d <-- data

Figure 5: SM Module Organization

5 RESULTS AND DISCUSSION

Since the state machine approach involves a systematic definition of process state, the resulting program is regular in structure. This makes it easy to read and understand. Code reviews, including other members of the development group as well as the programmer, found most of the bugs. The rest were captured by simulator testing. We feel that the debugging time was shorter than it would have been if a state machine approach had not been selected.

The portable nature of the state machines is noteworthy. All the control procedures are copied directly. The initialization, interrupt handler, state machine driver and the message protocol can be moved without change, which accounts for 60% to 70% of the code depending on the complexity of the state diagram.

We reused the design and most of the code on many peripheral cards: digitone receiver, exchange line, tie trunk and loop trunk cards.

Maintenance of the code once it is developed is very easy. Usually, in user application oriented development projects the specifications change very often. The changes are easily accommodated by adding some states or changing some timing parameters in the STM, etc.

The development time for the first state machine card (ALC) firmware was 10 man_weeks. Further peripheral card firmware development time was much shorter depending on the complexity of the state diagram of the new card. For example digitone receiver firmware was developed in about 4 man_week whereas the tietrunk firmware took about 14 man_weeks. This number includes the time from the specification through end of testing. The software schedules were met or bettered in most cases.

The disadvantage of the state machine approach is the additional run_time software needed to interpret the SM control constructs. However the processor idle time is such that this factor is of no concern. This depends on the number of units supported and how often the units are used. The range of idle processor time was measured at between 65% and 75%.

6 CONCLUSION

The decision to use the state machine architecture heavily depends on the requirements of the system. This state machine architecture may be used in peripheral processing systems of the type where a set of peripherals are monitored or controlled; usually most of the stored program controlled PBXs do have such requirements.

We would like to thank all the members of the scientific staff at BNR Inc., who contributed towards this paper either by way of discussion or constructive criticism.

A FUTURIST LOOKS AT TELECOMMUNICATIONS...or,
videotex, classic comics and the mechanical TV set

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This is a personal and sometimes critical overview of the telecommunications explosion of today, recalling a similar situation 30 years ago, and attempting to project a desirable system 30 years in the future. The overlooked role of direct radio broadcasting from satellites is discussed.

In reviewing the cellulose, non-miniaturized, non-electronic data bases created by the previous two Pacific Telecommunications Conferences, it struck me that while every specialist had his program, there was much that the generalist either couldn't understand, or was not interested in. So, I hope there may be room for a few personal opinions from the Emperor's fashion critic.

This past year I have been conducting a survey of telecommunications for the New Zealand Commission for the Future, naturally with a view to the whole Pacific Basin. The design point for the Commission has been the year 2010, now just about 30 years in the future.

To get a feeling for what 30 years really means, I started by looking backwards. Hindsight can equal insight. This little book illustrates the point. "Telecasting and Color" by Kingdon S. Tyler. Published in autumn 1946. World War II had just ended. Television was about to hit the consumer market. Mr. Tyler--the dutiful engineer, was telling the world what to expect. What he doesn't report on is as instructive as what he does describe.

As you might imagine, he has a comprehensive chapter on electronic tubes, or 'valves' if you prefer. And of course, not a word about transistors, microprocessors, diodes, LSI,MOS et cetera. Solid state electronics had not been invented.

He predicts that "coloured" television--that's his word, coloured, would be used first in the United States. He briefly mentions England, and some far-out all-electronic color television system. But there's not a word on Japan. In 1946, the role of Japan as an electronics giant was inconceivable. It was a vanquished foe; the first Pacific nuclear testing ground. Just over 30 years ago.

And what was this coloured television system he favoured? The new CBS mechanical colour wheel set. Does anyone remember it? The camera had a disc with red, blue and green segments spinning at 1440 rpm behind the lens. It transmitted three-colour separations sequentially as black and white signals, and there was another disc in the home set spinning at 720 rpm to re-create the colour. It worked fine,if you didn't mind having a buzzsaw inside your TV. The system was actually approved by the FCC and very nearly became the monopoly system for the whole United States. Fortunately, RCA and others raced in with a compatible all-electronic system just in time.

This 1946 book stresses the precision required in television studio production. Perfect timing, no mistakes. Why? Because there was no videotape, videodisc, video editing. Television was live! Period!

Another chapter is called "Television coast to coast." Here he had the beginnings of the answer. There was already a coaxial cable between New York and Schenectady. There was an application before the FCC for a microwave network in the western states. It was still an unproven technology, but it held the promise, according to Mr. Tyler, that you might be 3000 miles away from an event and still see and hear all that goes on. Television did slightly better when Neil Armstrong stepped in the moondust.

The boldest idea in 1946 was Stratovision by Westinghouse; television transmitters in a fleet of airplanes circling 30,000 feet above major cities. Each would cover some 100,000 square miles. Four aircraft would be needed for each location. One on-station and transmitting, a backup in the air, plus two on the ground for the next shift. Think of what the energy crisis would have done to the price of cornflakes if we relied on Stratovision today.

However, all of this was the first serious look at the problems of a nationwide video network. Listen to Mr. Tyler's closing words on the matter: "with network systems of this type, television stations could expect to receive fairly high revenue which would allow them to product excellent programs." No further comment.

With our gift of hindsight, where else would we have looked in 1946 for the true seeds of a telecommunications future?

It was just about a year earlier, that Arthur C. Clarke had overrun Stratovision and described the principles of geo-synchronous communications satellites. But Sputnik and Vanguard were more than a decade away, and besides, who would ever seriously consider an idea from someone who dabbled in Science Fiction.

ENIAC, the first electronic digital computer, was invented in 1946, but Mr. Tyler didn't associate it with communications. Its roomful of vacuum tubes and wires functioned at the incredible speed of 5000 additions per second.

Digital is a new word here. But any ham radio operator of 1946 might not be too surprised that his familiar dots and dashes could be translated to zeros and ones to carry information. However, the extent and impact of digitization a generation later might astound him.

Finally, the inventors of the World War II wire recorder might have stretched their imagination and envisioned videotape, floppy discs and magnetic bubbles.

The point is, that many of the roots of future telecommunications technology were around in the post-war period of 30 years ago, but I doubt if anyone could have recognized and assembled all the pieces. Describing the future is risky business, but we keep trying.

It seems to me that the chaotic situation facing Mr. Tyler parallels the total information slash communications slash computing explosion we are involved in today. His age had mechanical TV vs. all-electronic TV...coax vs. microwave vs. stratovision...VHF and UHF, plus, later on, frequency allocations for educational TV and a host of other conflicts. Today we have counterparts to all of these problems, and then some.

How may we characterize the two eras? New ideas and gadgets being Engineer-driven into the marketplace at a furious pace. A cut-throat filtering of these ideas by the Free Market, moderated and/or hamstrung by Governments. and, at the end of the line, a totally confused bunch of consumers. It is amazing that we have as much compatibility and standardization as we do.

I suspect that we are hearing a lot of words this week that someday will sound like Stratovision and mechanical TV sets. A massive amount of corporate blood and money is going to be spilled in the next few years as users put their money where their real needs and desires are.

(I should like to note that most of the following comments relate more to personal rather than business applications of our technologies. Business communications are a peculiar subset of the whole problem.)

What is the nature of the desirable pathways between today and the year 2010? Elegantly simple solutions to complex problems. Global compatabilities. Evolution rather than revolution. Improvements in all aspects of new systems, not tradeoffs and compromises.

What do I mean by that? Today, I could easily get a Fax machine and dial up my own electronic mail to the world of other Fax machines, at a relatively affordable cost. But my carefully typed original would come out looking like a third-generation drugstore photocopy. Today, I cannot afford the fancier systems that might solve the problem, and neither can my correspondants. So, we suffer the frustrations of the tangible mail system until affordable technology catches up.

In organizing thoughts on communications it helps to break them down into...two way, or interactive...one way, such as broadcasting and publishing...and no-way, meaning communicating with on-site memory or data bases.

For all two-way communications, the ideal model is the global telephone system. Consider its virtues. If you can count from one to ten, you can access it. You can speak English, French, Samoan or digital into one end, and at a single designated point, or at multiple points elsewhere around the planet, the same message comes out, the same way. In real time. With emotional overtones and cues, except of course for the digital. The telephone network has evolved over decades. The most modern computers can talk together, slowly of course, over twisted pairs that may have been pulled 30 years before ENIAC.

From New York, I would dial eleven digits to reach my office in Los Angeles. From Auckland, New Zealand, I simply add double zero to the number, and I get connected just as fast, just as clearly, although unfortunately not as cheaply. Still, virtually the whole globe is accessible at a maximum of $2.80 per minute from where I live.

Note that as a user of the phone system, I don't care if I am circuit switched, packet switched, TDMA, FDMA, C-band, X-band or rubber band. The system works, more often than not, and it is universally available. Let's build on those principles wherever possible.

Thirty years from now, where will our two-way telephone-model network be? I assume it will still be hardwired to every home and office in the civilized world. I assume it will be basically digital, and that most of the facilities yet to be installed will involve broadband transmission, probally at optical frequencies.

Terminals? I hope that it will be my choice and my business. As much or as little as I want to attach to the network. Maybe it's the free liquid-crystal display and keyset provided by my regional telemarket as an inducement to spending my credits with them. Maybe it's an all-up super-intelligent terminal with holographic display, automatic hourly updates of all new information in the universe, with non-invasive brain stem coupling. Or, I hope that I may still be able to use my black dial telephone with acoustic coupler and Apple.

I assume that on the other end of the network I will have access to global databanks and super number-crunchers, to all kinds of store and forward systems, to the wisdom of the ages, to vices and follies yet to be invented, and to cousin John. All in ultra-high fidelity, if I choose to pay for it...which brings us to the matter of current displays.

I am totally impatient with the Prestels, viewdatas and videotexes of today. Primitive is the nicest word I can think of for their display qualities. I prefer to think of them as the Classic Comics of the electronic age. Remember Classic Comics?...the world's greatest literature, public domain of course, in a garishly coloured 15 cent comic book. "Moby Dick, or subtitle: Captain Ahab and the one that got away." Timeless and deathless prose was chopped to fit in comic strip balloons. What is on a Prestel frame; about 150 carefully edited and passionless words; graphics that look like 'connect the dots' puzzles. "She may be smart, but she ain't pretty."

As a rule, I believe that any display which is inferior to the familiar raster-scan TV system wherever you may be, will need to improve to at least that TV standard to be accepted by the public. Unfortunately, that means more bandwidth, or an unforeseen breakthrough.

There's another time bomb in these systems that is not being considered seriously enough. Browsing. As a writer I want to browse. I depend on serendipity. I will gladly pay for it. Yet it is generally acknowledged that interactive systems are not for browsing. They have 'narrow information windows.' The New York Times is for browsing. There's my compromise; my tradeoff.

The opposite of browsing is "active searching." Using videotex is like going to the library. How many people do it. How often? Maybe the next generation of humans will find it painless, but I'm not sure.

And what about pricing? The early systems appear to be built on greed. Those global pots of pennies from page charges and interconnect tolls just may not exist on the scale required to keep everybody happy or solvent.

So, telecommunicators, please don't tell me that simply because you are promising immediacy and accessibility, I have to give up the image quality of a National Geographic sunset or a Playboy centerfold; that I can't browse through a Sunday Times-worth of information for a dollar or so; that I have to abandon the literary standards of the ages and settle for Mr. Toffler's "blips" of information. Even the Reader's Digest slips in a ten-page story from time to time, and their language is often "picturesque."

One-way communications--broadcasting and electronic publishing. Here again, I would personally like to see evolution in the direction of totally satellite-transmitted direct services. Too much good engineering skill, money and spectrum is still squandered on terrestrial transmitter systems that provide spotty coverage.

The momentum seems to be strong for solving the challenges of direct broadcast television. But what about direct broadcast radio? If anyone is working on it, I would like to hear from them. Last year, at PTC '80, I found no arguments against the proposal that satellite direct-broadcast radio transmission is an overlooked technological niche that is particularly relevant to the South Pacific. The uplinks are in place--Intelsat dishes. The technology of the receiver is available; a respected researcher says that a solar powered transistor-radio sized set might be mass-produced for under $50. The frequencies are not being used. Thousands of listeners in the Pacific with sparse service, or none at all, are waiting. Of course, the key is a fairly expensive and complex space segment, but it is well within 'state of the art.' It is my belief that most national radio services should be transmitted by satellite, along with complementary regional services. I should like to think that the Pacific Telecommunications Council might become an advocate for the research and development of such a service.

In any event, audio and video broadcasting from the sky will mature over the next 30 years. Conventional programming, teletext and other data services, electronic periodicals, weather services, landsat-type imaging, and on and on. But, just as it is possible to visualize the growth of global systems providing more types of services, it is also easy to project a shrinkage in the number of suppliers--of local broadcasters.

If Ted Turner goes direct, what happens to WKRP?...and to all the other struggling local stations? What will be the 'cultural imperialism' effects of direct broadcasting on nations such as Fiji, who have debated long and hard about the impact of television, and elected to stay out of the medium? It's impossible to legislate against signals from space.

I have to break out as a "special case" the wrist-terminal or personal locator that can link an individual to the world probably via satellite. I think it will come. I hope it will come. But the extent of services, and the complexities of networking and addressing such a system boggles me. The citizens band radio craze in the United States demonstrated the demand, but not the solution. Memory pagers and cellular radio seem to be crude first steps. I think we could agree that large chunks of spectrum must be reserved for future portable personal terminals. Certainly the South Pacific is one region that could benefit most from such a service, although it is not the type of mass market that will be needed to justify the development effort.

Finally, a word about what I call 'no-way' communications, or locally stored information. At this date it seems impossible to project the eventual winners in the videodisc, cassette and other memory media race. We may assume that one or two systems will prevail, and hopefully that they will be the most worthy ones.

What will be the role of stored information and how will it relate to the two-way and one-way functions discussed earlier? I suspect that as integrated home communications and computing centers become widespread, that stored information will displace many of the Prestel-type services currently envisioned; namely, those that do not rely on immediacy for their value.

Personally, I would rather pay $1,000 or even $10,000 for a videodisc album of the contents of the Library of Congress, than try to search it remotely. And I know that my son would find a way to record his own library of information from whatever source he can tap, just as today he builds his own audio cassettes of rock music from the radio.

The best of networks will go down, or get noisy or overloaded from time to time. The status of having a personal library will probably persist, at least with me.

I hope one day to be able to library the ultimate storage medium for the Pacific, and that it will be humidity proof, mildew proof and corrosion resistant. Then we can all sit around at home and teleconference about the good old days of 1981, when PTC proceedings were great for pressing Hawaiian flowers.

Telecommunications and Human Resource Development

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Abstract

The prospect for enhancing professional development programs based on information technology is the focus of this paper. An overview of emerging and existing techniques also will be presented. Some of the topics to be discussed are videodisc-computer configurations, audio-visual media centers and various teleconferencing systems for program delivery.

Information drives knowledge-based activities in much the same way as energy powers industry. Consequently, the abundance or paucity of these analogs will send ripples throughout their respective systems. The method and means of delivery become critical factors in achieving stable and productive operations. Technology has advanced to the point where the amount of telecommunication between machines will soon surpass person-to-person uses. On the other hand, the quality of personal interaction via telecommunications has not progressed much beyond the telephone as a talking letter and the television as an electronic newspaper. That is, until recently. Innovation and refinements in technology have resulted in the creation of completely new modes of communication. How these changes can be applied to human resource development is the focus of this paper.

Human resource development (HRD) relates to the training and information required by an individual for personal and/or professional needs. A recent text on the subject points to a change in this field. "No longer confined by earlier narrow definitions of 'training,' the profession has evolved to encompass a multitude of disciplines and approaches, all focused on the central goal of developing human potential in every aspect of lifelong learning." (1) The application of telecommunication to this "central goal of developing human potential" is important for three principal reasons. First, because there is an ever-present need to spend HRD funds in the most efficient manner possible. Second, is the need to maximize the efficacy of training and information programs. Third, to provide more and more people with the training and information they seek. Older methods are enhanced, not replaced, by new techniques.

Researchers have noted that the television, microcomputer and other sophisticated devices have not yet spawned the predicted revolution in education. (2) One reason for this is the fact that hardware alone won't transform any field. Planning is necessary, as is the willingness to try entirely new approaches to training designed to fit new media. Institutional arrangements amenable to the use of instructional technology must precede the purchase and installation of equipment. Otherwise, the expected benefits and savings can't be realized. Managing telecommunication systems requires knowledge of delivery systems and also an understanding of the process of communication itself. (3)

New systems for serving the needs of HRD must be thoroughly studied before acceptance or rejection is conferred. Through the general processes of planning, implementation and operation, managers and educators can develop policies to govern the use of instructional media systems. A whole array of factors including the technology, institutional setting, economics, politics and legal ramifications necessitate consideration. A National Research Council study concluded that "... it may be impossible to take full advantage of telecommunications potentials without some changes in the management structures in urban administrations." (4)

In order to put into perspective the relationship between telecommunications and HRD, it is useful to review some of the major applications in this area. However, the discussion is intended to illustrate general trends and emerging patterns of use not specific case histories. A selected bibliography of relevant sources has been included at the end of this paper for persons interested in additional information about a particular system or project. Because all of the following systems utilize a telecommunication link in some way, they also share common components such as terminals, transmission, switching and control. In addition, the software of these various systems all support the functions of education and training.

Telecommunication systems using aural, visual or print technologies assist information exchange, statistical reporting, problem solving, education and even decision making among people who may be separated by space and time. (5) The concept of teleconferencing as it relates to continuing education is only beginning to be explored. The idea, of course, is much older than any modern organization.

Audio or telephone conferencing is the most common and inexpensive method. One hybrid utilizes radio signals that may be transmitted via satellite links over wide distances. The satellite project at the University of the South Pacific is one example. (6) The more common form of audio teleconferencing utilizes telephone lines for transmission, and a bridging device for connecting all the locations on the same line. There are loudspeakers and microphones at each site.

Audio teleconferencing equipment can be permanently installed using dedicated lines for high quality voice transmission and reliability of service. Portable units also are utilized to conduct continuing education. One common problem in using this medium for group interaction is determining the order of speaking. Without visual cues, it is awkward to maintain a smooth, informal discussion between the groups on line. A possible solution being tested in Australia employs a computer that identifies who is speaking and displays the queueing order for subsequent speakers. (7)

Visual teleconferencing ranges from the simple to the sophisticated. Still pictures can be transmitted over phone lines with slow scan video devices or an electronic blackboard can be used. The more elegant varieties allow full motion two-way video communication with multiple cameras and accessories. The one-way video, two-way audio configuration has the broadest appeal to educators. This system allows the instructor to be seen and heard by the students. Interaction is possible on a voice basis. Many new businesses have been created to facilitate video-conferences and some major hotel chains are now entering this service area. Cable television systems are the logical collection and distribution points for networks serving human resource development. The growth of these systems should not be restricted to the distribution of broadcast programs. (8)

In the area of print media, telecommunication has been involved since the days of the first telegraph and continues to innovate with computer conferencing techniques. Computer conferencing has been described as the "strangest" form of teleconferencing. "With no images of the participants, nor voices, nor even a shared moment in time, a computer conference hardly seems like a 'meeting' at all." (9) With the proliferation of personal computers and electronic mail systems, this technique will become an effective inexpensive educational medium. Information systems can be adapted to assist learning-at-a-distance once the regulatory issues have been resolved. Viewdata and various teletext systems could provide tremendous resources to educators, but all this telematique can't be effective unless it is properly understood.

Another innovative use of telephone technology in continuing education is the dial access system. This system provides audio tapes (usually under 15 minutes in length) to callers. Some systems are fully automated which minimizes operation costs. Dial access programs would be very helpful in disseminating information about recent changes in a given field.

Computer and video technologies combine in many ways. Another example is microcomputer assisted videodisc projects for interactive instruction, group instruction and simulations. (10) The videodisc offers an ideal storage medium for educational material. The computer-assisted varieties are extremely interactive, allowing individuals to access self-paced learning modules and retain a record of each student's progress for the instructor. The cost of producing the original videodisc from which copies are made is approximately $2,000. Copies can be produced for less than $10 a piece. This makes videodisc technology similar to the costs and operation of the publishing industry.

Communication satellites have been used for projects and experimental programs in the field of education, but the competition for transponders grows more intense each year. The Public Service Satellite Consortium is a valuable resource for educators who are looking for ways to reach a national audience. With the advent of direct broadcast satellites will come additional means of delivering continuing education to specialized groups. The Region 2 planning conference scheduled for 1983 will consider proposals for the use and disposition of these satellites. Educators and other public interest groups should make their communication needs known to ensure adequate representation.

The interconnection of such technologies as cable television, computers, satellites, and the telephone hold enormous potential for improving service delivery in human resource development. By bridging the gap between urban and rural locations, new technology can improve the chances for equal opportunity in education and job advancement. The ability to provide two-way communication channels is a significant improvement over the one-way mass communication technology of broadcast media. Expanding the number of channels available for programming is also having an impact on education. The merging of various systems that were once distinct will erase old notions of learning and create new modes of communication.

The establishment of national clearinghouses for information educational technology should be encouraged. Perhaps the National Diffusion Network of/the Department of Education could be broadened to serve this purpose. National and regional conferences should be organized to give wider exposure to the benefits of these new systems. Demonstrating the utility of educational technology should be given high priority in governmental funding for education.

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